CONCRETE FIELD TECHNICIAN STUDY GUIDE

Materials & Tests Unit

NCDOT

Prepared by:
North Carolina Division of Highways
Material and Test Unit
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PREFACE

The following information on components of concrete and related subjects has been prepared *as* a practical study guide for technicians, batchers, inspectors, and contractor or producer personnel to help in preparing to become a Certified Concrete Field Technician. We have tried to make it as much a self-study guide as possible. The book has been arranged in the order it will be presented in our schools.

It should help serve as a source of information for the person starting in concrete work, as well as a reference book to those with considerable concrete construction experience. The objective is to train and educate so that the end results will be better quality concrete in the construction of our highways.

The information included in this book is generally compatible with current specifications and instructions; however, it should not be considered a specification. It should be used only as a guide and as a reference to supplement the reader's knowledge of concrete.

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Day 4

8:30am	- Review
10:00am	- ACI Written Test
11:10am	- NCDOT Written Test

NCDOT CONCRETE FIELD TECHNIAN SCHOOL CLASS EXAM

Components

1. The chemical reaction between water and cement is called _____________ .

2. List the basic components that are used to make concrete.
   _________, __________, _________, and __________.

3. There are __________ types of Portland cement.

4. Initial set takes place _____ to ________ hours after the cement has come in contact with the water.

5. Final setting takes place approximately ____ to _____ hours after the cement and water are placed in contact.

6. Fly Ash is a byproduct of :
   a) concrete
   b) sand
   c) the combustion of pulverized coal in coal power plants
   d) reaction between cement and water under pressure

7. What are the two most important characteristics when selecting a fly ash for concrete?
   a) Specific gravity and shape
   b) Reactivity and absorption
   c) Fineness and carbon content

8. According to NCDOT Standard Specifications fly ash may be substituted for Portland cement up to _________ by weight of the required cement.

9. The allowable pH range for mixing water used to batch concrete for NCDOT projects is ______ to ______.

10. Air entraining agent is added to concrete primarily to _________________________________.

11. Less air is entrained as the temperature of the concrete ____________________.

Specifications

12. Make sure the concrete temperature at the time of placement in the forms is not less than _________ °F nor more than _______ °F.

13. Do not place concrete when the air temperature is below ______ °F without permission.

14. A curing day is defined as any consecutive _______ period, beginning when the manipulation of each separate mass is ____________, during which the air temperature adjacent to the mass does not fall below ________ °F.

15. Use at least ______ percent of the rated mixing capacity as the minimum quantity of concrete permitted to be mixed or agitated in any mixer.

16. The ________________ will review the mix design for compliance with the Specifications and notify the ________________ as to its acceptability.

17. An air entraining agent is added at the time of mixing to produce air content in the range of _________________ for incidental and structural concrete when tested at the job site.
    a) 5.0 ± 1.5 percent
    b) 4.5 ± 1.5 percent
    c) 6.0 ± 1.0 percent
    d) 6.0 ± 1.5 percent

18. Use an approved set retarding admixture in all concrete placed in the superstructure of bridges. True or False

19. When concrete is being produced for structures and incidental construction have present during all batching operations a ______________________ employed by the Contractor or concrete supplier.
    a) Certified Concrete Field Technician
    b) Certified Concrete Batch Technician

20. The component easiest and most practical to cool in concrete is _________.

Policies

21. When using 6” x 12” cylindrical specimens for strength determination, place the concrete in _____ layers of approximately equal volume.

22. The minimum set of cylinders that can be made for a Class AA concrete pour of 100 cubic yards concrete is ___________.

23. When an air entraining agent is added on the jobsite to bring concrete within specifications, the concrete must be mixed ________ revolutions at mixing speed.

24. Mix designs for structural concrete shall be submitted to the Engineer _______ before proposed use.

Frequently Asked Questions: REGARDING CONCRETE PRODUCTION

The following FAQ's pertain to the production of concrete which will be utilized on existing or potential NCDOT Projects.

- Question: What is Alkali Silica Reaction (ASR)?

  Answer: The **Alkali-Silica Reaction** (ASR) is a reaction which occurs over time in concrete between the highly alkaline cement paste and reactive silica, which is found in many common aggregates.

- Question: What if the aggregate source supplying aggregate at my plant is not on the NCDOT approved list?

  Answer: You can not produce for NCDOT and must get an approved source to supply your plant with aggregate in compliance with NCDOT Specifications.

- Question: Do I need to record the actual batch quantities and the individual batch weights?

  Answer: Yes, all quantities and weights must be computer generated or hand printed, but must be recorded for each batch produced (policy letter dated August 29, 2000).

- Question: What certification do I need to batch concrete for NCDOT?

  Answer: Concrete Batching Technician Certification. Batchers of Concrete Pavement must have a Pavement Concrete Technician Certification also.

- Question: If my Concrete Batch Technician Certification is current, do I need to keep my Field Technician Certificate current?

  Answer: Yes, if you will be involved in the sampling and testing of the plastic concrete. If you are batching only, and not testing concrete, you only need to keep the batch certification current.

- Question: Do I need to run a moisture test on coarse aggregate?

  Answer: Yes, the certified batcher is required to check moisture contents by the drying method on both fine and coarse aggregate a minimum of twice a day or whenever deemed necessary. These moisture calculations are to be recorded, documented and stored with the producer's copy of the batch weight tickets.

- Question: What if the moisture the batcher computes is different from the moisture the computer indicates?

  Answer: The batcher must have the capability to change/update the moisture contents for both fine and coarse aggregate **<u>prior</u>** to batching. This correction is to be performed at the batching facility and not at the central dispatch location.

- Question: What if the moistures are not changed in the computer?

  Answer: The batcher and plant certifications will be investigated. Disciplinary actions may be implemented towards the facility.

- Question: Does the batcher need to review the approved mix design?

  Answer: Yes, the certified batcher is responsible for all production of concrete. All sources of materials should be correct on site and approved by NCDOT. If any producer/facility source on the mix design is different than on site, you must submit a new mix design or get the approved materials.

- Question: What paperwork is required on the materials?

  Answer: The plant is responsible for and must supply current copies of certifications for all cement, fly ash, slag, fine and coarse aggregates, all admixtures, and the water source. In addition, all sources must be on the "NCDOT Approved List".

- Question: Where is the approved NCDOT list located?

  Answer: Approved sources for materials used in concrete are located on the Materials and Tests web site ncdot.org/~mtu. The Physical Testing Laboratory group link lead to the approve lists.

- Question: Should the plant and batcher have a hard copy of the approved mix design?

  Answer: Yes, the certified Batch Technician is responsible for assuring that the materials and proportions shown on the approved mix design are incorporated into the concrete. Therefore a hard copy of the mix design must be present when batching a NCDOT concrete mix.

- Question: How does the DOT keep track of mix designs?

  Answer: By use of two electronic databases. The Concrete Mix Design database is a plant-by-plant list of mix designs accepted for each plant. Data on each mix design includes mix number, class, proportions, mix properties, material sources, and material properties. Acceptance of a mix design in this database does not constitute its acceptance for any contract. Assignment of mix designs to contracts involves a separate submittal, review and acceptance procedure via the Concrete Mix Contract Assignment database. Mix designs must be in the Concrete Mix Design database to qualify for assignment to a contract. Upon written request from the Engineer for specific mix designs to be assigned to a contract, the Physical Testing Engineer reviews and assigns these mix designs in the Concrete Mix Contract Assignment database. This database shows the list of mix designs assigned to each contract. Requests for mix design approval for contracts outside the scope of HiCams are handled similarly except that the Concrete Mix Contract Assignment database is not used, in which case approved hard copies are returned to the Engineer for distribution.

- Question: How do I submit a mix design for the Mix Design database?

Answer: Complete Materials and Tests Form 312U (English units only) and mail it to Physical Testing Engineer, NCDOT, Materials & Tests Unit, 1801 Blue Ridge Rd., Raleigh, NC 27607.

- Question: How do I submit mix designs for a contract?

  Answer: It is the contractor's responsibility to submit such requests to the NCDOT Engineer administering the contract. The contractor should request the concrete producer to complete M & T Form 312R, Mix Design Request Form, for each plant he plans to use to supply concrete and forward these forms to him for submittal to the Engineer.

- Question: Do I need to submit strength test results with each mix design?

  Answer: For structural and incidental concrete, DOT Standard Specifications require laboratory test results of 7- and 28-day compressive strength for each mix. For concrete paving, laboratory test results of 28-day (formerly 14-day) flexural strength of each mix are required. See Section 1000 of the 2006 Standard Specifications for details. See below for exceptions.

- Question: May I submit compressive strength results from a three-point curve instead of from individual mix designs to cover all my structural and incidental mixes designed with the same materials?

  Answer: Yes, for Class AA, AA-barrier rail, A, B and B-curb & gutter machine mixes only.

- Question: If I want to change a source of material but retain its quantity in an approved mix design, do I need to submit strength results?

  Answer: We permit source changes of cement, fly ash, ground granulated blast furnace slag, silica fume, water and admixtures without strength results. However, you must assign each altered mix design a new producer mix number and submit each new mix design for the database. If you change an aggregate source, you need to submit strength data.

- Question: May I change quantities of materials in an approved mix without submitting strength data?

  Answer: No, except where changes in aggregate quantity are necessitated by significant specific gravity changes, in which case you should notify the Physical Testing Engineer for instructions.

- Question: My ACI Certification is good for another year, but my Field Technician certification expired this year. May I continue to test concrete and batch concrete for another year (provided my Batch Certification is good for another year)?

  Answer: Once the Field Technician Certification expires, the technician is not allowed to sample and test plastic concrete until the certificate is renewed. If the technician holds a current batch certification, he or she is still able to batch until the batch certification expires. While the ACI certification may still be current, NCDOT requires a current Field Technician certification for testing and sampling plastic concrete. The ACI is a component of the Field Technician certification.
- Question: Who is required to be Mix Design certified?

Answer: The designated person submitting the mix design must be Mix Design certified.

- Question: My truck driver who is field tech certified informed me the concrete was not sampled properly during acceptance testing by project personnel. What should I do?

  Answer: Once an error of this type is exposed, immediately notify the project personnel. In addition, inform the M&T Concrete Technician of the problem. Document the specific procedure you feel was run incorrectly. Keep a record including date, ticket number, project, and structure where the concrete is placed.

- Question: Do I physically have to be present in the batch room when concrete is batched for a NCDOT project? May I be on the premises, monitoring the batch process via two-way radio?

  Answer: The batcher must be physically present during batching of concrete on a NCDOT project. The certified batcher should be the one actually batching the concrete, not supervising someone who is not certified.

- Question: I just discovered the wrong mix design was used to batch concrete for a NCDOT project. Whom do I notify about this mistake? Will I lose my certification?

  Answer: Once an error of this type is discovered, immediately notify project personnel. The M&T concrete technician should also be informed of the error. Depending on the circumstances, the error will not necessarily lead to loss of your certification. The batcher should still maintain all required documentation. The 903 form should reflect the mix design that was used. The worst possible thing to do in this case is to attempt to alter records to cover up the mistake.

- Question: I am not getting my mix designs after they have been approved. I am required to have copy of the mix design when I batch concrete. What has happened to my copy?

  Answer: The contractor is actually the party that submits the mix design through the DOT Engineer responsible for the project to the Physical Testing Engineer. The Physical Testing Engineer returns the approved mix design to the NCDOT Engineer, who in turn returns the approved mix design to the contractor.

- Question: The mix I batched is stronger than the mix design approved. Why is this a problem?

  Answer: Strength is one measure of acceptance for DOT concrete. There are also durability issues. Approval of a mix design is based on several factors, including history of the performance of the mix submitted. Once approval is granted, deviating from the approved mix design creates an unknown product.

NCDOT / ACI EXAMINATION PROCEDURES AND REQUIREMENTS

Obtaining the NCDOT / ACI Certification: All Students must have a passing grade on both the written (Part 1) and Field Performance (Part 2) examinations as described herein:

PART 1: Written Examinations

NCDOT Written Exam:
Exam Duration: 1 hour
Minimum Passing Grade: 80%
Question Format: various types of questions, requiring

- fill in the blanks,
- multiple choice,
- hand calculations,
- composite questions (question composed of various parts)

Areas Covered:

- Class discussion
- NCDOT book (sections I, II, III, IV, V)

How to Prepare for this Exam?

- Follow class presentation and discussion
- Study the NCDOT Concrete Field Technician study guide
- Review homework questions, take home exam, and quiz

ACI Written Exam:
Exam Duration: 1 hour
Number of Questions: 55 total (covering 7 sections, one for each ASTM Standard Test)
Minimum Passing Grades: 60% on each section; 70% overall test
Question Format: various types of questions, answers require a multiple choice decision, selecting the correct answer will require knowledge of the ASTM standard and/or hand calculations.
Areas Covered:

- Only the 7 ASTM Standard Test Methods (see below)

How to Prepare for this Exam?

- Follow class presentation and discussion
- Study the ASTM Standard Test Methods contained in the ACI Technician Publication CP-1
- Review homework questions

Passing PART 1: All Students must have a passing grade in the NCDOT and ACI Written Exams to have a passing grade on Part 1

PART 2: Field Performance Examinations

Exam Duration:

NCDOT Field Performance (Chace Examination):	approximately 5 minutes/student
ACI and NCDOT Field Performance (7 ASTM Standard Tests):	approximately 3 hours/class

Areas Covered:

- NCDOT Field Performance: Students must correctly perform all procedural steps required by the Chace Indicator Test (AASHTO T-199) in accordance to a check list developed by the NCDOT
- ACI and NCDOT Field Performance: Students must perform correctly all procedural steps required by each of 7 ASTM Standard Tests (see table below), in accordance to a check list developed by the ACI. Proficiency with regard to ASTM C-172 (Sampling Freshly Mixed Concrete) will be demonstrated by taking an oral examination, in accordance with corresponding check list developed by the ACI.

Criteria

- All ACI and NCDOT Field Performance Exams will be graded on a pass/fail basis.
- A passing grade on any given ACI and NCDOT Field Performance Exam will be determined by having a passing grade in all and each of the procedural steps required for each test, as noted in the corresponding performance check list.

Exam Format:

- Students complete the required paperwork for all exam materials. Then, students are assigned to a test station, walk to the test station, hand-out exams materials to the examiner, perform each test, and receives a pass/fail grade in the test. The process is repeated until all tests are completed.
- No verbal interaction or questions are allowed during the examination
- If the student believes that he/she did NOT conduct a test in accordance with all required procedures, the student can consider a test "retrial" (a voluntary suspension of the test). This can be done while conducting the test, or right after he/she completes all test procedures, but **before** the examiner determines a pass or fail grade for that specific test.
- The student has a maximum of **two trials** to perform each test satisfactorily (a maximum of three times if the student used a "retrial" option in any of the two allowed trials).
- A "retrial" test can be conducted immediately after the student uses a voluntary suspension of a test; the same examiner can conduct this "retrial", or, the student can request another examiner for this purpose.
- A failed test requires that the student returns to queue line and waits for a next turn to conduct another trial; the student can request a different examiner after having failing a test.

How to Prepare for this Exam?

- Follow class presentation and discussion
- Study the ASTM Standard Test Methods contained in the ACI CP-1 Publication
- Study Section V in the NCDOT Concrete Field Technician study guide
- Review homework questions
- Use the allowed practice time wisely: ask questions, try each test.

Passing PART 2: All Students must have a passing grade in the NCDOT and ACI Field Performance Tests to have a passing grade on Part 2

<u>NCDOT / ACI FIELD TESTS</u>

TESTS	NCDOT (AASHTO)	ACI (ASTM)
Temperature of Freshly Mixed Concrete		C-1064
Sampling Freshly Mixed Concrete	T-141	C-172
Slump of Hydraulic-Cement Concrete	T-119	C-143
Density (Unit Weight)	T-121	C-138
Air Content by Pressure Meter	T-152	C-231
Air Content by Volumetric Method	T-196	C-173
Making and Curing Test Specimens	T-23	C-31
Air Content by Chace Indicator*	T-199	

* NOTES:
1) As indicated in the scope of AASHTO T-199, Standard Method of Test for Air Content of Freshly Mixed Concrete by the Chace Indicator, this method has been found satisfactory for determining the **<u>approximate</u>** air content of freshly mixed concrete. This method should not be considered suitable for replacing gravimetric, volumetric or pressure methods. This method is most useful for determining whether the concrete has low, medium, or high air contents, and whether the air content is reasonably constant from batch to batch of concrete.
2) Consistent with NOTE 1), the NCDOT requires that each and every load of concrete be tested using the Chace Indicator Test.
3) The NCDOT requires that: a) the cup be tamped after rodding is completed, b) the Chace indicator be fully assembled prior to the introduction of isopropyl alcohol, and c) the alcohol level be read to the nearest ¼ graduation.

SECTION I

COMPONENTS OF CONCRETE

INTRODUCTION

Concrete is a manufactured product that has two main phase components: aggregates and paste. Aggregates are normally of two types, fine and coarse, and occupy about 60 to 80 percent of the volume of the concrete. The paste is typically composed of cement, water, and entrained air. The paste ordinarily constitutes about 20 to 40 percent of the total volume of the concrete.

In properly manufactured concrete, the aggregate phase should consist of particles having adequate strength and weather resistance and should not contain materials having injurious effects. Well graded aggregates have a uniform size distribution and a low void content. Well graded aggregates allow for an efficient use of the paste fraction since, in quality concrete production, the paste must completely coat each aggregate particle and fill the space between them.

The quality of the concrete is greatly dependent upon the quality of the paste. In turn, the quality of the paste is dictated by the quality and control imposed over of the paste main components (cement, water, air), and by the extent of curing provided after the concrete mixture is in place. The use of proper quantities of water and cement in a concrete mixture can be monitored through the use of the water to cement ratio concept (quantity of water / quantity of cement). The water/cement ratio has the greatest effect on strength, durability, and water tightness of concrete. For a given quantity of cement, the strength and durability of the concrete will decrease with increased amounts of water. All other things remaining equal, the strength of the concrete will decrease with increased amounts of entrained air. Cement and water combine chemically in a reaction, called hydration. The hydration process can continue for a long period of time in favorable moisture conditions. The quantity of water used in a typical concrete mixture is greater than the quantity required for the hydration to occur, and is necessary to provide plasticity and workability to the concrete mixture. Strength gain ends when hydration stops.

Desirable Properties of Concrete

1. **Durability:** Ability of hardened concrete to resist deterioration caused by weathering, chemicals, and abrasion.
2. **Workability:** Ease of placing, handling, and finishing.
3. **Weather Resistant:** Resistance to deterioration caused by: freezing and thawing, wetting and drying, and heating and cooling.
4. **Erosion Resistant:** Resistance to deterioration caused by: water flow, traffic, and wind blasting.
5. **Chemical Resistant:** Resistance to deterioration caused by: deicing salts, salt water, and sulfate salts.
6. **Water Tightness:** Resistance to water infiltration.
7. **Strong**
8. **Economical**

CONCRETE INGREDIENTS

Portland Cement

The invention of Portland cement is credited to Joseph Aspdin, an English mason, in 1824. He named his product Portland cement because it produced a concrete which resembled a natural limestone quarried in England on the Isle of Portland.

Portland cements and blended cements (which incorporate pozzolan and/or siliceous mineral admixtures to normally manufactured Portland cements) are hydraulic since they set and harden to form a stone-like mass by reacting with water. The term hydraulic cement is an all inclusive term that includes both Portland cement and blended cement. Cement is the bonding agent used in a concrete mix.

Cement Manufacture

Different raw materials can be combined to manufacture cement. Typical raw materials include limestone, marl or oyster shells, shale, clay, and iron ore. Raw materials are selected, proportioned and pulverized to contribute appropriate proportions of lime, silica, alumina, and iron which are necessary to make the desired chemical composition for any given cement. This is done in a dry process (i.e., grinding and blending dry materials) or, in a slurry process. During the manufacturing process, raw and mixed materials are frequently tested and analyzed to ensure the quality and consistency of the cement. Once blended, the raw materials are fed into the upper end of a kiln and slowly transported to the lower end of the kiln where the mixture is exposed to burning fuel temperatures of 2600°F to 3000°F. The high temperatures induce various chemical reactions which result in the formation of the cement clinker. The clinker is then cooled and ground until it is reduced to very fine particles (pulverized). Most of these particles pass a sieve having 40,000 openings per square inch. During the grinding operation, gypsum is added to control the setting time of the cement. The pulverized finished product, mixed with adequate amounts of set-controlling gypsum, is known as Portland cement.

Cement Types

There are five types of Portland cement (I, II, III, IV, V), each manufactured to meet different needs and therefore having somewhat different physical and chemical characteristics.

Type I is a normal, general-purpose cement. It is suitable for all uses when the special properties of the other cement types are not required.

Type II cement generates less heat, at a slower rate, and has a moderate resistance to sulfate attack. It can also be used in structures of considerable mass, such as large piers, heavy abutments, and heavy retaining walls to control temperature rise within the concrete and/or in warm or hot weather concreting. Type II is also used when sulfate concentrations in ground waters are higher than normal.

Type III is a high-early-strength-cement. It develops higher strength at an earlier age. It is used when early form removal is desired. Alternatively, richer mixtures (with higher cement content) of Types I and II may be used to gain early strength.

Type IV cement has a low heat of hydration and develops strength at a slower rate than other cement types. It is used in massive concrete structures, such as dams. This type of cement is for use where there is a little chance for the heat to escape from the concrete mass, and when temperature control is critical.

Type V cement is used in concrete exposed to a severe sulfate exposure. It is used mainly where concrete is exposed to severe sulfate action such as concrete structures exposed to soil and groundwater with high sulfate content.

Cement Composition

A blended cement results when a portland cement is combined with a pozzolan (i.e., fly ash) or with a siliceous mineral admixture (i.e., slag). A pozzolan, such as fly ash, has no cementing qualities by itself. However, when a pozzolan is combined with water and calcium hydroxide (contained in a portland cement), the resulting mixture has a cementing affect.

Portland cements may be considered as composed of the following four basic chemical ingredients:

Tricalcium Silicate	$3CaO\text{-}SiO_2$	C_3S
Dicalcium Silicate	$2CaO\text{-}SiO_2$	C_2S
Tricalcium Aluminate	$3CaO\text{-}Al_2O_3$	C_3A
Tetracalcium Aluminoferrite	$4CaO\text{-}Al_2O_3\ Fe_2O_3$	C_4AF

Typical constituents of Portland clinker

Clinker	Mass%
Tricalcium silicate	45-75
Dicalcium silicate	7-32
Tricalcium aluminate	0-13
Tetracalcium aluminoferrite	0-18
Gypsum	2-10

The student should not attempt to memorize these chemical formulas, but should be familiar with the contribution that each compound makes to the concrete.

Tricalcium Silicate hardens rapidly and is largely responsible for initial set and early strength.

Dicalcium Silicate hardens slowly and contributes to strength increases at ages beyond one week.

Tricalcium Aluminate liberates heat during the first few days of hardening and it contributes slightly to early strength. Cement with low percentages of these compounds is especially resistant to sulfates (Type II and Type V).

Tetracalcium Aluminoferrite formation reduces the clinkering temperature, thereby assisting in the manufacture of cement. It hydrates rapidly but contributes very little to the strength.

Gypsum is added to achieve the desired setting qualities of the finished cement.

Table 1

TYPICAL CALCULATED COMPOUND COMPOSITION AND FINENESS OF PORTLAND CEMENTS

Types of Portland Cement		**Compound Composition* and Fineness****				
ASTM	**CSA**	**C_3S (%)**	**C_2S (%)**	**C_3A (%)**	**C_4AF (%)**	**Fineness (cm^2/gr)**
I	Normal	50	24	11	8	1800
II		42	33	5	13	1800
III	High-Early-Strength	60	13	9	8	2600
IV		26	50	5	12	1900
V	Sulfate-Resisting	40	40	4	9	1900

* Typical composition. Deviations from these values do not indicate unsatisfactory performance. For specification limits see
ASTM C150 or AASHTO M85.
** Fineness as determined by Wagner turbidimeter test.

Table 2

APPROXIMATE RELATIVE STRENGTHS OF CONCRETE AS AFFECTED BY TYPE OF CEMENT

Type of Portland Cement		**Compressive strength** (As a percentage of the strength achieved by a Type I or normal portland cement concrete)			
ASTM	CSA	1 Day	7 Days	28 Days	90 Days
I	Normal	100	100	100	100
II		75	85	90	100
III	High-Early-Strength	190	120	110	100
IV		55	55	75	100
V	Sulfate-Resisting	65	75	85	100

Cement Properties

1. Fineness

The fineness of cement affects the rate of hydration. As cement fineness increases, the surface area of the cement particles increases. Therefore, the rate of reaction increases, and the strength development is accelerated.

2. Setting Time
A cement paste must remain plastic long enough to permit normal placing and finishing. The length of time that a concrete mixture remains plastic depends more on the temperature and water content of the paste than on the setting time of the cement.

3. False Set
False set is evidenced by a significant loss of plasticity shortly after the concrete is mixed. Further mixing without the addition of water can restore plasticity. There are several factors that promote false set; the most common is heating of the cement during grinding operations.

4. Heat of Hydration
Heat of hydration is the heat generated when cement and water react. The amount of heat generated is dependent chiefly upon the chemical composition of the cement. The rate of heat generation is affected by the fineness of the cement, the temperature of curing, and the chemical composition of the cement.

5. Quick Set or Flash Set
Quick Set or Flash Set usually occurs when Portland cement is insufficiently retarded; the time of initial setting is considerably less than one hour at normal temperatures. Quick set may be due to insufficient or faulty gypsum in the Portland cement, or to improper chemical composition of the clinker. The chemical reactions involved liberate a large amount of heat and the set cannot be overcome by remixing the paste.

6. Specific Gravity
Specific gravity is the ratio resulting from dividing the solid weight of a material to the weight of an equal volume of water at standard conditions of temperature and pressure. The specific gravity of Portland cement is generally about 3.15.

Shipping and Storage

Most cement is shipped in bulk by railroad, barges or truck. One bag of cement weights 94 pounds. Portland cement must be kept dry in order for its quality to be retained.

Hydration Process

The chemical process by which cement reacts with water is called “hydration”. This process involves many different reactions often occurring at the same time. As the reactions proceed, heat is liberated (exothermic reaction) and the products of the hydration process gradually bond the concrete components. It is possible to get an indication of the rate at which cement minerals and water are reacting by monitoring the fluidity and the rate at which heat is generated in the concrete mixture.

As soon as water is in contact with cement, the clinker sulfates and the gypsum dissolve producing an alkaline, sulfate-rich solution. The tricalcium aluminate (C_3A), the most reactive component of the cement), reacts with the water to form an aluminate-rich gel. The gel reacts with sulfate in solution to form small rod-like crystals of ettringite. The C_3A initial hydration is strongly exothermic, “coats” the cement particles, but it does not last long; typically only a few minutes; this initial reaction is followed by a period of low heat evolution as the “coating” layer thickens. This is called the “dormant” period which can last 40 to 120 minutes depending on various chemical and environmental conditions. The first and medium portions of the dormant period correspond to the time when concrete can be placed. As the dormant period progresses, the concrete becomes too stiff to be workable.

At the end of the dormant period, the “coating” is cleaned by dissolution. Then, the alite and belite in the cement start to hydrate with the formation of calcium silicate hydrate and calcium hydroxide. A period of accelerating chemical reactions resumes. This corresponds to the main period of cement hydration, during which the strength of the concrete increases. The cement grains react from the surface inwards, and the anhydrous particles become smaller. The C_3A hydration continues, as fresh crystals become accessible to water. Water in hydrated pastes may be arbitrarily classified into evaporable water and non-evaporable water, the latter being water not removed under standard drying conditions, or chemically bound water. The period of maximum heat evolution occurs typically between 10 and 20 hours after mixing and gradually tails off.

Setting Time

During the hydration process (and after the “dormant” period) the concrete paste gradually loses its plasticity, shows signs of stiffness, and then becomes a stiff mass but without any sizeable strength. The time and degrees of relative stiffness can be measured by a standard test method which allows the determination of both the initial set and final set of a given concrete mixture.

Initial setting defines the point in time when the concrete is no longer fluid and shows the first signs of stiffening. Initial set takes place approximately 2 to 4 hours after the cement has come into contact with the water.

Final setting defines the point in time when the concrete has completely lost its fluidity and shows the consistency of a stiff mass but without any appreciable strength. Final set in a typical concrete mixture takes place approximately 5 to 8 hours after the cement and water were placed in contact.

One should recognize that the “setting” process is associated with fluidity of the concrete mass, and is not necessarily accompanied by a drying process; it takes place even if the fresh cement paste is kept under water. The strength development process, also known as “hardening”, is associated with strength gain and takes place after the concrete reaches final setting.

As discussed previously in the section on “hydration”, both the “setting” and “hardening” processes are the result of a series of simultaneous and consecutive chemical reactions between water and the constituents of portland cement.

Fly Ash

Fly ash is a byproduct of the combustion of pulverized coal in coal-fired power plants. It is removed by mechanical collectors or electrostatic precipitators as a fine particulate residue from the combustion gases before they are discharged to the atmosphere.

Fly ash particles are typically spherical, ranging in diameter from 1 to 150 micron. The range of particle sizes in any given fly ash is largely determined by the type of system utilized for dust collection. The fly ash from boilers, where mechanical collectors alone are employed, is coarser than fly ash from plants using electrostatic precipitators.

The chemical composition of fly ash is determined by the types and relative amounts of mineral matter in the coal used in the combustion process. More than 85 percent of most fly ashes comprise chemical compounds and gases formed from SiO_2, Al_2O_3, CaO and MgO. Generally, fly ash produced from the combustion of sub-bituminous coals contains more CaO and less Fe_2O_3 than fly ash from bituminous coal. Varying amounts of unburned carbon particles remain in the fly ash as it is collected. This residue depends on such factors as the rate of combustion, air-fuel ratio, and the degree of pulverization of the coal. The recognition that fly ash frequently exhibits pozzolanic properties has led to its use as a constituent of concrete.

A pozzolan is defined as “a siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value but, in finely divided form and in the presence of moisture, it will chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.” Only a few power plants produce an “ideal” fly ash (with a combination of high fineness and low carbon content). Some plants produce a coarse fly ash, with low carbon content and low fineness. This type of fly ash can be satisfactory used in concrete provided that laboratory tests confirm its beneficial performance. A coarse fly ash would be a much improved pozzolan if it were ground to meet the requirements of ASTM C-618.

Types of Pozzolanic Materials

Class N: Raw or calcined natural pozzolans

1. Clays and shales: montmorillonite, kaolinite, and illite types.
2. Opaline materials: opaline cherts and shales, and diatomaceous earths.
3. Volcanic tuffs and pumicites: rhyolitic, andesitic, phonolitic and basaltic types.

Class F: Fly ash normally produced from burning anthracite or bituminous coal that meets the applicable requirements for this class as given in ASTM C 618. This fly ash has pozzolanic properties.

Class C: Fly ash normally produced from lignite or sub-bituminous coal that meets the applicable requirements for this class as given in ASTN C 618. This class of fly ash, in addition to having pozzolanic properties, also has some cementitious properties. Some Class C fly ashes may contain lime contents higher than 10%.

Class S: Any pozzolan that meets the applicable requirements for this class as given in ASTM C 618. Examples of materials in this class include certain processed pumicites, and certain calcined and ground shales, clays, and diatomites.

Potential Benefits of Using a Pozzolan in Concrete

Cement is the most expensive component of a concrete mixture. The introduction of a pozzolan in a concrete mixture can improve the fresh and hardened properties of a concrete mixture while reducing its costs. Some of the effects of using a pozzolan in a concrete mixture are listed below:

In Fresh Concrete:

1. Reduced water requirements of the mixture, especially when the pozzolan is fly ash.
2. Increased workability, reduced bleeding and segregation.

In Hardened Concrete:

1. Modification of the mixture's strength development characteristics by postponing strength gain; this can increase plastic flow at early ages and reduce cracking.
2. Reduced drying shrinkage.
3. Improved water tightness of the concrete.
4. Improved resistance to sulfate active soils and waters with high sulfate content.
5. Inhibited and/or reduced alkali-aggregate reaction.
6. Reduce adiabatic heat of hydration of massive members.

Potential Deleterious Effects of Using High Carbon Fly Ash in Concrete

Unburned, residual, carbon in fly ash can have a dual detrimental effect in concrete. First, unburned carbon particles will tend to float to the surface due to their low density and can cause discoloration problems in the concrete. Second, unburned carbon particles can affect both the amount and stability of air entrained agents (AEA) used in concrete, thus affecting the cost and the freeze and thaw durability of the concrete. Consistently low carbon content is extremely desirable in a fly ash to maintain and control the air content in a concrete mixture.

Selecting Fly Ash for Use in Concrete

When selecting a fly ash for concrete, fineness and carbon content are the two most important characteristics. The carbon content of fly ash can range from 1 percent to as high as 30 percent. For best results the carbon content should be relatively low (no more than 6 percent) and the fineness should be relatively high (a specific surface of more than 2500 cm^2/gm). The NCDOT Standard Specifications require that fly ash must meet the requirements of ASTM C 618, for Class F or Class C except that the loss on ignition shall not exceed 4 percent. Fly ash shall also meet the optional physical requirements for uniformity as shown in Table 2A of ASTM C 618.

Fly ash particles are generally finer than cement particles; the Blaine fineness generally ranges between 2000 and 6000 cm^2/gm for a typical fly ash. A fly ash having finer particles is generally preferred for use in concrete, as it will generally promote higher strength. The specific gravity of fly ash generally ranges between 1.88 and 2.84, with the finer particles having higher specific gravities.

NCDOT Standard Specifications for Fly Ash and Slag

1. Use of Fly Ash

Provide fly ash that meets ASTM C618 for Class F or Class C. The loss on ignition must not exceed 4%. Fly ash may be substituted for a portion of Portland cement in all classes of concrete. In all classes, except Class 5, fly ash may be substituted for Portland cement up to 20% by weight of the required cement noted in Table 1000-1 of the Standard Specifications on Roadway and Structures. Substitution shall be at the rate of at least 1.2 pounds of fly ash per pound of cement. Do not substitute fly ash for a portion of Type IP or IS cement or for Portland cement in high early strength concrete.

The maximum water cement ratio based on total cementitious materials shall be as follows for each class of concrete when using a fly ash mix.

Fly Ash Maximum Water Cementitious Ratios

Class of Concrete	Rounded Aggregate	Angular Aggregate
AA & AA Slip Form	.366	.410
A	.469	.512
B & B Slip Form	.469	.545
Pavement	.538	.538

The Contractor shall furnish the Engineer 5 copies of a Type 4 Materials Certification, in accordance with Article 106-3 of the Standard Specifications from each supplier furnishing fly ash. The laboratory which performs the tests included in the certification shall be regularly inspected by the Cement and Concrete Reference Laboratory (CCRL) for fly ash testing and shall authorize CCRL to submit a copy of the inspection reports directly to the Materials and Tests Unit of the Department. The Certification shall state that the fly ash to be used in the project meets the requirements of Article 1024-5. Upon receipt of this certification the fly ash may be used prior to testing by the Department. All fly ash will be sampled and tested by the Department as it arrives on the project at such frequency as established by the Department.

2. Use of Ground Granulated Blast Furnace Slag

Blast-furnace slag is a nonmetallic product, consisting essentially of silicates and alumino-silicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace. Granulated blast-furnace slag is the glassy, granular material formed when molten blast-furnace slag is rapidly chilled, by immersion in water.

Granulated blast furnace slag may be substituted for a portion of Portland Cement in all classes of concrete except Class S. Slag may be substituted for up to 50% of the required cement on a pound for pound basis. Water cement ratio shall remain as shown on Table 1000-1. Slag shall not be substituted for a portion of Type 1P or 1S cement or for Portland cement in high early strength concrete. Blast-furnace slag shall meet the requirements of AASHTO M 302, Grade 100.

The Contractor shall furnish the Engineer 5 copies of a Type 5 Certification, in accordance with Article 106-3, from each supplier furnishing concrete. The Certification shall state the blast furnace Slag to be used in the concrete meets the requirements of Article 1024-6. Upon receipt of this Certification, the slag may be sampled and tested by the Department as it arrives on the project at such frequency as may be established by the Department.

Mixing Water

Almost any natural water that is drinkable is satisfactory as mixing water for making or curing concrete. However, water suitable for making concrete may not be necessarily fit for drinking. Water is added during batching of the concrete volumetrically or by weight. To add all the components in concrete in like units, it may be necessary to convert gallons of water to ponds of water. The conversion factor used is 1 gallon of water weighs 8.33 pounds. For example,

32.0 gallons of water x 8.33 = 267 pounds of water

Water used in batching of concrete must be moderate in alkalinity and acidity. The acceptance of acid or alkaline waters is based on the pH scale which ranges from 0 to 14. The pH of neutral water is 7.0. A pH below 7.0 indicates acidity, and a pH above 7.0 indicates alkalinity. The pH of mixing water should be between 4.5 and 8.5. Unless approved by tests, water from the following sources should not be used:

1. Water containing inorganic salts such as manganese, tin, zinc, copper or lead.
2. Industrial waste waters from tanneries, paint and paper factories, coke plants, chemical and galvanizing plants, etc.
3. Waters carrying sanitary sewage or organic silt.
4. Waters containing small amounts of sugar, oil, or algae.

pH SCALE

1 **ACIDITY**
2
3
4
5 --→ 4.5
6 **Acceptable pH range of mixing water**
7 **NEUTRAL**
8
9 --→ 8.5
10
11
12
13
14 **ALKALINITY**

Aggregates

Aggregates must conform to certain requirements and should consist of clean, hard, strong, and durable particles; free of chemicals, coatings of clay, or other fine materials that may affect the hydration and bond of the cement paste. Aggregates characteristics influence the properties of concrete.

Weak, friable or laminated aggregate particles are undesirable. A well graded aggregate with a low void content is desired for efficient use of paste. Aggregates containing natural shale or shaly particles, soft and porous particles, and certain types of chert should be especially avoided since they have poor resistance to weathering. In a properly made concrete mix the concrete should consist of particles having adequate strength and suitable weather resistance.

Characteristics of Aggregates

1. Resistance to Freezing and Thawing - (Important in structures subjected to weathering): The freeze-thaw resistance of an aggregate is related to its porosity, absorption, and pore structure. NCDOT Specifications require that resistance to weathering be demonstrated by the sodium sulfate test.

2. Abrasion Resistance - (Important in pavements, loading platforms, floors, etc.): Abrasion resistance is the ability to withstand loads without excessive wear or deterioration of the aggregate. NCDOT Specifications require that abrasion resistance be demonstrated by the Los Angeles Abrasion Test.

3. Chemical Stability - (Important to strength and durability of all types of structures.): Aggregates must not be reactive with cement alkalies. This reaction may cause abnormal expansion and map-cracking of concrete.

4. Particle Shape and Surface Texture - (Important to the workability of fresh concrete): Rough textures or flat and elongated particles, require more water to produce workable concrete than do rounded or cubical aggregates.

5. Grading - (Important to the workability of fresh concrete): Grading or particle size distribution of an aggregate is determined by a sieve analysis: As can be seen in Figure 1, grading (size distribution) and particle size can affect important properties of concrete such as cementitious requirements and ability to entrain air.

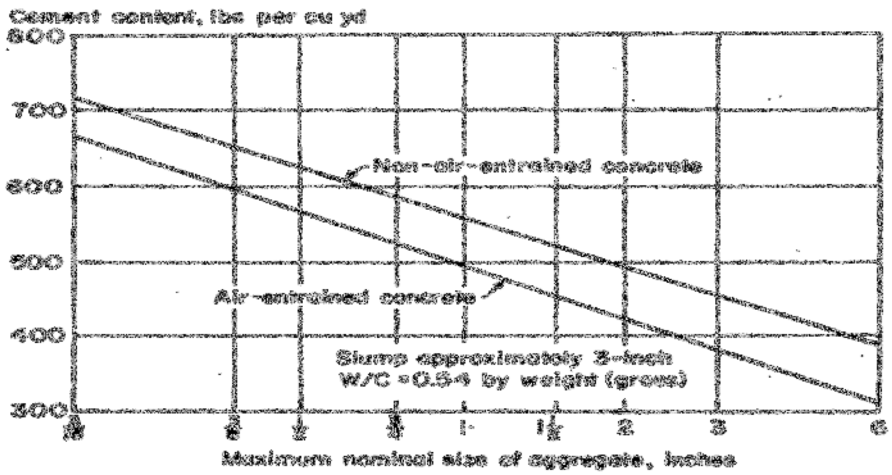


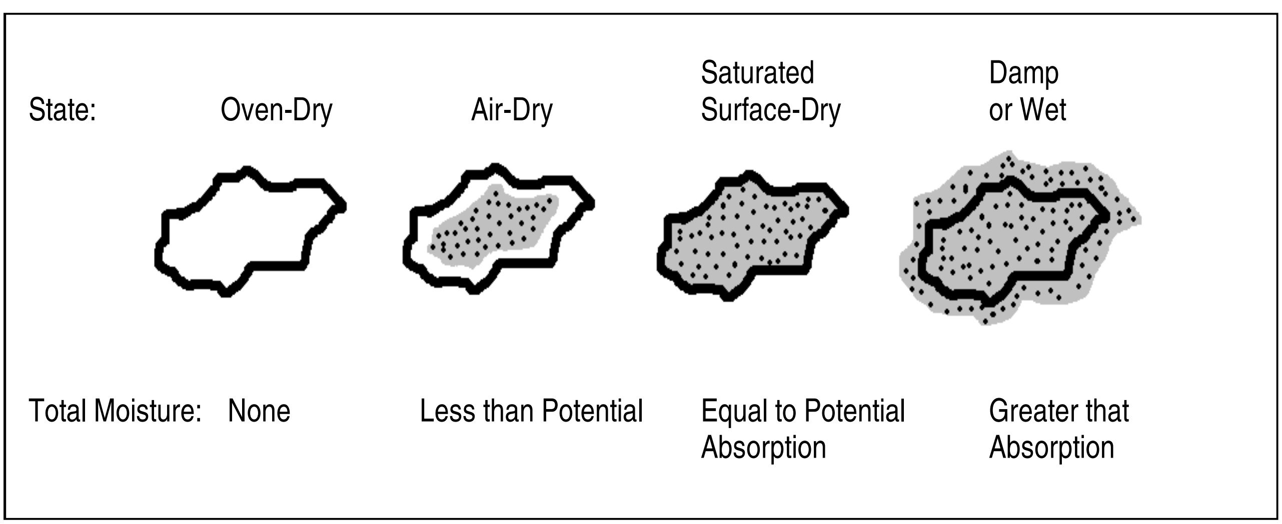
Fig. 1 - The water requirement for concrete of a given consistency decreases as the maximum size of coarse aggregate increases.

6. Specific Gravity - The specific gravity of an aggregate is the ratio of its solid weight to the weight of an equal volume of water at a given temperature and pressure. Most normal weight aggregates have specific gravity in the range of 2.4 to 2.9. It is not a measure of aggregate quality. It is used to calculate mixture proportions.

7. Absorption and moisture - The moisture conditions of an aggregate are shown in Figure 2. They are designated as:

a) **Oven Dry**: completely dry, thus fully absorbent
b) **Air-Dry**: dry at the surface but containing some interior moisture, thus somewhat absorbent.
c) **Saturated Surface-Dry (SSD)**: neither absorbing water from, nor contributing water to, the concrete mixture.
d) **Wet with Free Moisture**: containing an excess of moisture on the surface.

Batch weights of materials must be adjusted for moisture conditions of the aggregates.



8. Dry-rodded Unit Weight: Is the weight of one cubic foot of dry coarse aggregate that is compacted by rodding in a standard container in three equal layers. For any aggregate, the dry rodded unit weight varies with the particle size and gradation.

Deleterious Substances in Aggregates

Deleterious substances in aggregates are harmful substances and their types and effects in concrete include the following:

1. **Organic Impurities:** affect setting and hardening, and may cause deterioration.
2. **Material finer than #200 sieve:** affects bond and increases water demand.
3. **Lightweight Materials (coal, lignite):** affect durability, and may cause pop-outs and stains.
4. **Soft Particles:** affect durability and wear resistance.
5. **Friable Particles:** affect workability and durability; can break up during mixing and increase water demand.
6. **Clay Lumps:** absorb water and can cause pop-outs in hardened concrete.

Admixtures

Admixtures include all materials other than cement, water and aggregates that are added to concrete. Admixtures can be broadly classified as follows:

1. Air-entraining
2. Retarding
3. Water-reducing
4. Accelerating (only used in special circumstances)
5. Pozzolans
6. Workability agents
7. Miscellaneous, such as permeability-reducing agent, gas forming agents, and grouting agents
8. Water-reducing and retarding
9. Water-reducing and accelerating (only used in special circumstances)
10. Superplasticizers

Concrete should be workable, finishable, strong, durable, watertight, and wear-resistant. These qualities can often be obtained without the use of chemical admixtures (except for air-entraining admixtures) by using suitable materials and properly proportioning the mixture. There may be instances when special properties may be desired such as extended time of set, acceleration of strength, or a reduction in shrinkage. These types of concrete characteristics can be obtained by the use of admixtures. However, admixtures in general (any type or quantity) should not be considered as a substitute for good concrete practices.

The effectiveness of an admixture depends on various factors such as the type and amount of cement, water content, aggregate shape, gradation, proportions, mixing time, slump, and temperature (both concrete and air). Trial mixtures should be made to observe the impact of admixtures in the properties of the concrete (fresh and hardened), and to insure compatibility between admixtures. When introduced into the concrete admixture should be added with the mixing water.

Air-Entraining Admixtures

Concrete that is not air-entrained contains mostly entrapped air. Concrete that is air-entrained contains both entrained air as well as reduced amounts of entrapped air (depending on various factors including the degree and quality of consolidation). Entrained air is characterized by microscopic air bubbles that are well distributed, but not interconnected, throughout the cement paste. These bubbles are small and invisible to the naked eye. Entrapped air is composed of visible air voids that occur randomly in all concrete mixtures. The amount of entrapped air is largely a function of aggregate characteristics and degree of consolidation.

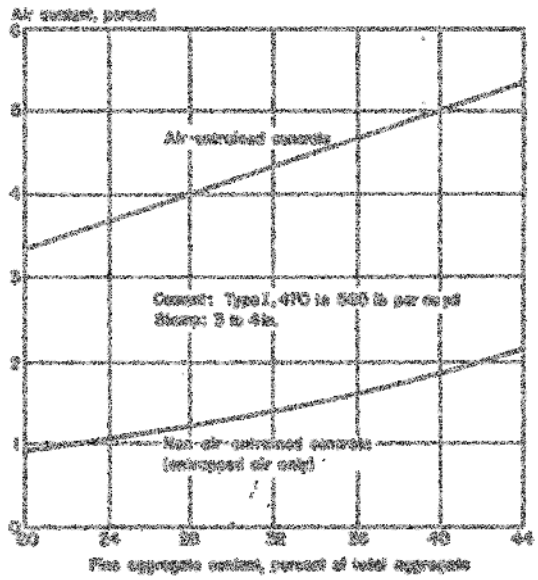
A concrete mixture can experience variations on its air content. These variations are the result of different factors such as aggregate proportions, gradation, mixing time, temperature, and slump. Adequate control is required to ensure the proper air content at all times. Since the amount of air-entraining agent per batch is relatively small (i.e., 3 to 8 oz. per cubic yard of concrete), it is important to first disperse the agent in the mixing water prior to mixing, and then proceed with the mixing process. This is important to achieve proper spacing, size and uniform distribution of the air voids within the concrete to achieve adequate freeze and thaw protection of the concrete.

Effects of Entrained Air on Concrete

1. **Durability (Freeze Thaw Resistance):** Is improved as air voids act as reservoirs which relieve the pressure of expanding water as it freezes. This prevents damage to the concrete. Air entraining agent is added to concrete primarily for increased Freeze Thaw Resistance, or Durability.
2. **Workability:** Is improved. Sand and water contents can be reduced. The plastic mass is more cohesive and looks and feels “fatty” or “workable”. As water is reduced, segregation and bleeding of the mixture can also be reduced.
3. **Resistance to Deicing:** Surface scaling is reduced.
4. **Sulfate Resistance:** Is improved.
5. **Strength:** Is reduced (if the only change is increased air). Strength depends upon the voids/cement ratio. “Voids” is defined as the total volume of water plus air (entrained and entrapped). If all things remain equal, and the only affected factor is an increase in the amount of air voids, then the concrete strength will decrease. However, strength reduction can be minimized because the improved workability allows for a lower water-cement ratio.
6. **Abrasion Resistance:** About the same as non-air-entrained concrete of the same compressive strength.

Factors Affecting Air Content

1. **Coarse Aggregate Gradation:** For given cement content there is little change in air content when the maximum nominal size of the aggregate is increased above 1-1/4 inch. For aggregate sizes smaller than ¼ inch, the air content increases sharply as the size decreases because of the increase in mortar volume (See Fig 4).
2. **Fine Aggregate Content:** An increase in the amount of fine aggregate causes an increase in air content with a given amount of air-entraining agent. (See Fig. 3).
3. **Cement Content:** As the cement increases, the air content decreases (See Fig.4).



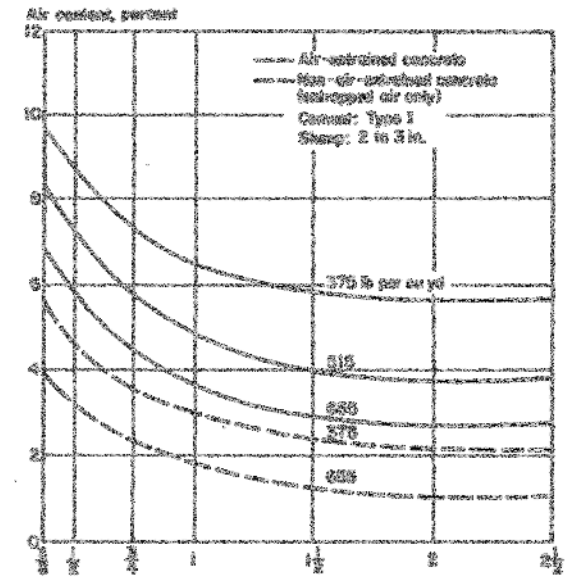


Fig. 3 - Relationship between percentage of fine. aggregate and air content of concrete.

Fig. 4 - Relationship between aggregate size. cement content, and air of concrete

4. **Slump:** The air content increases as the slump increases up to about 7 inches, and decreases with further increases in slump.
5. **Vibration:** Prolonged vibration should be avoided. Regardless of the slump, 15 seconds of vibration causes a considerable reduction in air content. If vibration is properly applied, little of the intentionally entrained air is lost. Air lost during handling and vibration consists mostly of entrapped air, which large bubbles are undesirable for strength and finishability.
6. **Temperature:** Less air is entrained as the temperature of the concrete increases.
7. **Mixing Action:** The amount of entrained air varies with the type and condition of the mixer, the mixing rate, and amount of concrete being mixed. Figure 5 shows the effect of mixing speed and mixing time in a transit mixer. Figure 6 shows the effect on air content as agitating time is increased.

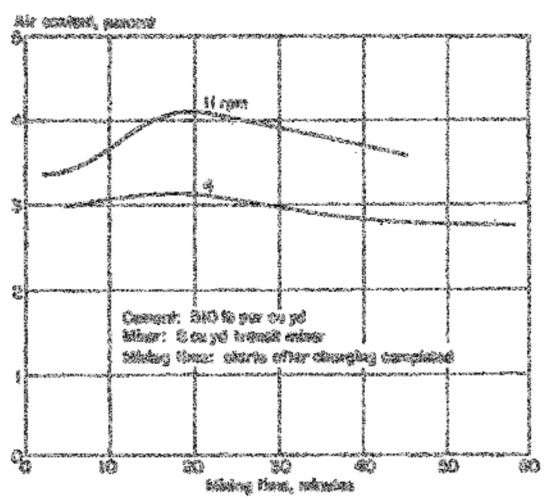


Fig.5 - Relationship between mixing time and air content of concrete

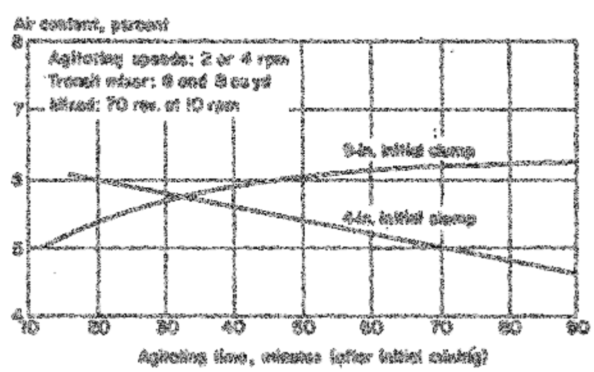


Fig.6 - Relationship between agitating time, air content, and slump of concrete.

The amount of air specified in air-entrained concrete depends on the type of structure and the extent of exposure to deicing chemicals, freeze-thaw cycles, and chemically reacting soils or waters.

Retarding Admixtures

A retarding admixture is a material that is used for the purpose of delaying the setting time of concrete. Retarders are used in concrete to:

1. Offset the accelerating effect of hot weather on the setting of concrete.
2. Provide time for placing, or finishing, critical members such as bridge decks or large piers.

All retarders, listed on the NCDOT approved list, also function as water reducers. These are frequently called "water-reducing retarders." Some retarders also entrain some air in concrete. A retarded concrete may lose slump faster than a non-retarded concrete. Because some retarding admixtures react with certain air-entraining admixtures, they are introduced into the mixing water separately. Retarders must be subjected to performance testing in trial mixtures to be acceptable. Testing ensures that the retarder is compatible with all the ingredients in the mixture and that adverse effects would not impair the fresh and hardened properties of concrete. All retarders used in NCDOT concrete placements must be on the NCDOT approved list.
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Water-reducing Admixtures

A water-reducing admixture is a material used for the purpose of reducing the quantity of mixing water required to produce a concrete mixture of a given consistency. These materials increase the slump of concrete for given water content. A water reduction of about 5% is possible for a given slump.

Many water-reducing admixtures may also retard the setting time of concrete. Some water-reducing admixtures can also entrain air into the concrete. An increase in strength can generally be obtained with water-reducing admixtures if the water content is reduced and if the cement content and slump are kept the same. A rapid loss in slump, and a significant increase in drying shrinkage, can result from the use of some of these admixtures. Therefore, trail batch tests should be made with job materials.

Accelerating Admixtures

An accelerating admixture is used to accelerate the setting time and the strength development of concrete. The rate of strength gain in concrete can also be accelerated by:

1. Using Type III Cement
2. Lowering the water-cement ratio, or increasing the cement content
3. Cure concrete at higher temperatures

Most of the commonly used accelerators cause an increase in the drying shrinkage of concrete. Calcium chloride is the most commonly used accelerating admixture. Calcium chloride and other materials used as accelerators are not antifreeze agents. When used in normal amounts, accelerators can slightly reduce the freezing point of concrete by only a few degrees.

Calcium chloride should be added in solution as part of the mixing water in amounts not to exceed two percent by weight of cement. A greater amount can result in placement problems and can be detrimental to concrete, since it may cause rapid stiffening, increased drying shrinkage, and corrosion of the steel reinforcement. The addition of no more than two percent of calcium chloride has no significant corrosive effect on ordinary steel reinforcement, provided the concrete is of high quality.

Many commercial admixtures contain calcium chloride and are not recommended for use in items such as:

1. Prestressed concrete
2. Concrete with embedded aluminum conduit
3. Concrete with galvanized steel reinforcement
4. Concrete subject to alkali-aggregate reaction

North Carolina Specifications do not allow the use of an accelerator except when approved by the Engineer.

High Range Water Reducing Admixtures (Superplasticizers)

A superplasticizer is a high range water reducing admixture. These materials reduce water in the 12 to 20% range. Dosage rates are typically specified in ounces of admixture per 100 lbs. of cement used in the concrete mixture. The dosage rate is usually recommended by the manufacturer.

Effects of using a superplasticizer

1. Recommended for concrete to the pumped or tremied.
2. Allows lower water-cement ratios, which will result in higher strengths.
3. Increased flow-ability for a placement where vibration cannot be achieved.
4. Labor could be reduced.
5. Shrinkage cracking may be reduced due to lower water content.
6. Recommended for precast work, such as prestress concrete, where early strengths are required to release concrete beds for production purposes.

Many superplasticizers lose workability within 30 to 60 minutes depending on conditions and dosage rates. Some may entrain air and retard the setting time. If slump becomes too high, it is possible to have segregation; drying shrinkage may also become a problem. Trial batches should be checked with job materials before using superplasticizers.

ALKALI-SILICA REACTIVITY

Alkali-Silica Reactivity (ASR) is a chemical reaction that deteriorates hardened concrete. The reaction occurs when alkali rich fluid present in concrete react with reactive siliceous minerals in the aggregate. The product of this reaction is a gel that may absorb water and increase in volume over time. The presence of the alkali-silicate gel does not always cause damage to the concrete; however gels of the appropriate formation can absorb large quantities of water. The major problem that results from the absorption of large quantities of water is that pressure generated by the increased volume ruptures the aggregate particles and causes cracking. Reactions usually become visible in five to ten years after placement of concrete. Typical indicators of ASR are random map cracking, closed joints, and spalled concrete.

The progress of the reaction can be extremely slow, and signs of ASR may only appear after the concrete is years to decades old. The tensile strength and elastic modulus of the concrete are compromised as the severity of the reaction develops, but compressive strength is usually little affected. ASR problems may be more aesthetic than structural, providing the concrete is well reinforced. However durability of the affected concrete is compromised by ASR.

Three items have to be present for ASR to take place:

- Reactive Aggregates
- Alkalis
- Water

If any of the three items is missing, the reaction will not take place.

Alkalinity in cement is expressed as the sodium-oxide equivalent. By specification (article 1024.1) the cement's sodium-oxide shall not exceed 1.0 %. When using non reactive aggregates and cement with an alkali content less than 0.6%, straight cement mixes are allowed. Concrete mixes using reactive aggregates, or cement with alkali content between 0.6%-1.0%, must use a supplementary cementitious material. For mixes that contain cement with an alkali content between 0.6% and 1.0%, and for mixes that contain a reactive aggregate documented by the Department, regardless of the alkali content of the cement, use a pozzolan in the amount shown in Table 1024-1.

Table 1024-1	
Pozzolans for Use in Portland Cement Concrete	
Pozzolan	*Rate*
Class F Fly Ash	20% by weight of required cement content, with 1.2 lbs Class F fly ash per lb of cement replaced
Ground Granulated Blast Furnace Slag	35%-50% by weight of required cement content with 1 lb slag per lb of cement replaced
Microsilica	4%-8% by weight of required cement content, with 1 lb microsilica per lb of cement replaced

There is an accelerated test for ASR potential of aggregates; however the results are difficult to match up with actual field conditions. The potential for generating false positive or false negative results is considerable. Cement is not the only source of soluble alkalis in concrete. Contributions from the aggregates, mix water, and chemical admixtures need to be assessed. Actual performance in the field provides the most information concerning the aggregate reactivity.

STUDY QUESTIONS
(COMPONENTS OF CONCRETE)

1. A mixture of cement paste and fine aggregate is called:
   A. Concrete
   B. Mortar
   C. Paste
   D. Coarse Aggregate

2. The chemical reaction between water and cement is called:
   A. Hydration
   B. Cement Factor
   C. Natural Cement
   D. Unit weight

3. A pH value of 7.0 indicates:
   A. Neutrality
   B. Alkalinity
   C. Acidity
   D. All of the above

4. The property that reflects the ease or difficulty in placing and finishing freshly mixed concrete, is called:
   A. Workability
   B. Hydration
   C. Durability
   D. Harshness

5. A chemical, such as calcium chloride, used to "speed up" the setting time of concrete is called:
   A. Hydration
   B. False set
   C. Retarder
   D. Accelerator

6. A significant loss of plasticity (without heat generation) shortly after the concrete is mixed is called:
   A. Fineness of cement
   B. Heat of hydration
   C. False set
   D. Batch Operator Error

7. The time it takes a cement paste to have the consistency of a stiff mass is known as:
   A. High early strength
   B. Flash set
   C. Final setting
   D. False set

8. The bonding agent used in a concrete mix is:
   A. Water
   B. Set retarder
   C. Cement
   D. Aggregate

9. A by-product of the combustion of pulverized coal in a Coal-Fired power plant is:
   A. Cement
   B. Carbon
   C. Admixture
   D. Fly Ash

10. A material used for the purpose of delaying the setting time of concrete is:
    A. Retarding admixture
    B. Water reducing agent
    C. Accelerator
    D. Superplasticizer

11. The pH limits of mixing water to be used in NCDOT concrete are:
    A. 1.0 -12.0
    B. 4.5 - 7.0
    C. 4.5 - 7.5
    D. None of the above

12. The weight of one gallon of water is:
    A. 6.65 pounds
    B. 10.25 pounds
    C. 8.33 pounds
    D. 5.00 pounds

13. The ability of hardened concrete to resist the deterioration caused by weathering, chemicals, and abrasions is known as:
    A. Consistency
    B. Durability
    C. Flexibility
    D. Workability

14. The specific gravity of Portland cement is:
    A. 1.00
    B. 2.65
    C. 3.15
    D. 4.50

15. The NCDOT allowable range for air content in incidental and structural concrete is:
    A. 2.0 - 5.5
    B. 3.5 - 7.5
    C. 4.5 - 7.5
    D. 4.5 - 8.5

16. The most important effect of entrained air in concrete is to:
    A. Increase strength
    B. Decrease mixing water
    C. Increase workability
    D. Increase durability

17. Concrete should have the desired slump before beginning any other tests.
    A. True
    B. False

18. Two desirable properties of an aggregate are (one correct answer):
    A. High porosity and inert
    B. Low absorption and abrasive resistance
    C. High porosity and laminated
    D. Laminated and cubical shape

19. Admixtures must be dispersed into the concrete mixer with:
    A. Cement
    B. Water
    C. Fine aggregate
    D. Coarse aggregate

20. What are the three important factors in curing concrete:
    A. Time, Temperature, Moisture
    B. Time, Moisture, Cement
    C. Time, Temperature, Sun
    D. Sun, Wind, Heat

21. The type of cement which has the highest fineness and the highest amount of tricalcium silicate, both factors contributing to accelerated strength gain, is:
    A. Type I
    B. Type II
    C. Type III
    D. Type IV

22. In NCDOT mixtures fly ash may be substituted for Portland cement up to ______ by weight of the specified cement:
    A. 10%
    B. 20%
    C. 30%
    D. 40%

23. Which of the following has the greatest effect on the strength, durability, and water tightness of concrete:
    A. Aggregate durability
    B. Color of cement
    C. Cement content
    D. Water-cement ratio

24. Concrete should have the desired ________ before beginning any other tests.
    A. Color
    B. Slump
    C. Smell
    D. All of the above

SECTION II

2006 STANDARD SPECIFICATIONS
FOR
ROADS AND STRUCTURES

SECTION 420 & 1000

CONCRETE STRUCTURES

420-1 DESCRIPTION

Construct cast-in-place concrete structures and the cast-in-place concrete portions of composite structures in conformity with the lines, grades, and dimensions shown in the contract. Furnish and place concrete, joint filler and sealer, curing agents, epoxy protective coating, deck drains, expansion anchors, and any other material; erect and remove all falsework and forms; protect concrete in wind, rain, low humidity, high temperatures, or other unfavorable weather; construct joints and weep holes; finish and cure concrete; protect concrete from rust stains; and groove bridge floors. For reinforced concrete deck slabs, in addition to the above, furnish and place reinforcing steel and bridge scuppers; and design, furnish, erect, and remove all bridge deck forms including any appurtenances required by the Engineer to stabilize exterior girders during overhang construction.

420-2 MATERIALS

Refer to Division 10:

Item	Section
Portland Cement Concrete	1000
Reinforcing Steel	1070
Curing Agents	1026
Joint Fillers	1028-1
Joint Sealers	1028
Deck Drains	1054-3
Expansion Anchors	1074-2
Metal Stay-in-Place Forms	1074-12
Calcium Nitrite Corrosion Inhibitor	1000-4(K)
Epoxy Protective Coating	1081

420-3 FALSEWORK AND FORMS

(A) General

Submit 8 sets of detailed drawings for falsework or forms for bridge superstructure and other components as required by the contract for review, comments and acceptance before beginning construction of the falsework or forms. This review does not relieve the Contractor of full responsibility for the safety, alignment, quality, or finish of the work.

Design falsework and forms to carry the full loads upon them, including a dead load of 150 pounds per cubic foot for concrete, loads caused by equipment and personnel, and for lateral pressures resulting from rate of pours, setting times, and effects of vibration on the concrete, so that the finished concrete surface conforms to the proper dimensions and contours and has an even appearance.

Use lumber and other material for forms and falsework that is sound and in good condition.

Set falsework and forms to give the correct elevation shown on the drawings making proper allowance for shrinkage, deflections, and settlement, and maintain true to lines and grades designated until the concrete sufficiently hardens.

Where falsework or forms appear to be unsatisfactorily built in any respect either before or during placing of concrete, the Engineer will order the work stopped until the defects are acceptably corrected.

Keep the falsework and forms in place after placing of concrete for the periods specified in Article 420-16. Remove falsework and forms in an acceptable manner. Do not leave forms or falsework permanently in place without written approval.

Provide a means, satisfactory to the Engineer, to check any settlement or deflection that may occur during the placing of concrete in the various portions of the work.

(B) Falsework

Build falsework on foundations of sufficient strength to carry the applied loads without appreciable settlement. Support falsework that cannot be founded on solid footings on ample falsework piling.

Use an acceptable method to compensate for shrinkage, deflection, and settlement. Use jacks in order to readily effect adjustment, if necessary, before or during placing of concrete, if required by the Engineer.

(C) Forms

(1) General
Use forms made of wood or steel except where other materials are specified by the contract or accepted by the Engineer.

(2) Wood Forms
Build forms mortar-tight of material sufficient in strength with ample studding, walling, and bracing to effectively prevent any appreciable horizontal and/or vertical deflection.

Provide forms with interior dimensions such that the finished concrete is of the form and dimensions shown on the plans.

Line forms, except for surfaces permanently in contact with earth fill, with plywood or other approved material. Provide a lining with a smooth and uniform texture and of such thickness and rigidity that a concrete surface of uniform texture and even appearance results. Provide joints between form liners that are mortar tight and even and maintain to prevent the opening of joints due to the shrinkage of the lumber.

Fillet forms at all sharp corners unless otherwise noted on the plans. Mill wood chamfer strips from straight grained lumber and surface on all sides.

Give forms for all projections a bevel or draft to insure easy removal.

At all times, maintain the shape, strength, rigidity, watertightness, and surface smoothness of reused forms. Resize any warped or bulged lumber before reusing. Do not reuse any forms that are unsatisfactory in any respect. Do not use plywood sheets showing torn grain, worn edges, patches or holes from previous use, or other defects that impair the texture of concrete surfaces exposed to view.

Maintain an acceptable alignment and no broken edges on all chamfer strips.

Thoroughly clean forms previously used of all dirt, mortar, and foreign material before reusing. Before placing concrete in forms to be removed, thoroughly coat all inside surfaces of the forms with commercial quality form oil or other equivalent coating which permits the ready release of the forms and does not discolor the concrete.

Construct or install metal spacers or anchorages, required within the forms for their support or to hold them in correct alignment and location, in such a way that the metal work can be removed to a depth of at least 1" from the exposed surface of the concrete without injury to such surface by spalling or otherwise. Limit the diameter to not greater than 1½ times its depth for the recess formed in the concrete. Cut back all such metal devices in exposed surfaces, upon removal of the forms, to a depth of at least 1" from the face of the concrete. Carefully fill cavities produced by the removal of metal devices with cement mortar of the same mix used in the body of the work immediately upon removal of the forms, and leave the surface smooth, even, and as nearly uniform in color as possible. As an option, break off flush with the concrete surface those metal devices with cross sectional area not exceeding 0.05 square inches on surfaces permanently in contact with earth fill.

Do not weld metal devices to either reinforcing steel or structural steel that is a permanent part of the structure without written approval.

(3) Steel Forms

Apply the requirements of Subarticle 420-3(C)(2) in regards to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, texture and evenness of appearance of the resulting concrete surface, removal, re-use, and oiling to steel forms. Use steel for forms of such thickness that the forms remain true to shape. Counter-sink bolt and rivet heads. Design clamps, pins, or other connecting devices to hold the forms rigidly together and allow removal without injury to the concrete. Do not use steel forms that do not present a smooth surface or line up properly. Exercise care to keep steel forms free from rust, grease, or other foreign matter that will tend to discolor the concrete.

(D) Forms for Concrete Bridge Decks

In addition to the requirements of Subarticles 420-3(C)(1) through 420-3(C)(3), the following requirements apply to falsework and forms used to construct reinforced concrete bridge decks on girders. Furnish all materials, labor, equipment and incidentals necessary for the proper installation of falsework and forms for concrete bridge deck slabs.

For prestressed girder spans, the plans for the concrete deck slab are detailed for the use of a cast-in-place slab using either precast prestressed concrete panels or fabricated metal stay-in-place forms; however, as an option, construct a cast-in-place slab using removable forms. If noted on the plans, the option is available to use metal stay-in-place forms in lieu of precast prestressed concrete panels.

For structural steel spans, plans for the concrete deck slab are detailed for the use of metal stay-in-place forms; however, as an option, construct a cast-in-place slab using removable forms. Do not use precast prestressed concrete panels on structural steel spans.

If using a form system other than that detailed on the plans, do so at no additional cost to the Department. Changes in slab design to accommodate the use of optional forms are the responsibility of the Contractor. Submit these changes for review and approval. Prior to using optional forms, submit two sets of prints of detailed checked plans of the system and checked design calculations for the composite slab complying to the latest *AASHTO Standard Specifications* and *Highway Design Branch Structure Design Manual.* After the drawings are reviewed and, if necessary, the corrections made, submit reproducible drawings of the deck system to become the revised plans. Ensure that the size of the sheets used for the drawings is 22" x 34". Ensure that the plans and design calculations are checked and sealed by a North Carolina Licensed Professional Engineer.

Where reinforced concrete deck slab with sand lightweight concrete is required by the contract, do not use precast prestressed concrete panels.

Unless otherwise shown on the plans, use the same forming system for all of the same type superstructure spans within the bridge. Construct the slab overhang from the exterior girder to the outside edge of superstructure using removable forms.

(1) Precast Prestressed Concrete Panels

Prestressed concrete panels are subject to the requirements for prestressed concrete members as specified in Section 1078, the plans, and these Specifications.

Design prestressed panels subject to review by the Engineer. Prior to using prestressed panels, submit 7 sets, including one reproducible set, of detailed plans of the panels for review. Submit with the checked plans 1 set of checked design calculations for the panels complying with the latest *AASHTO Standard Specifications*, requirements detailed herein, and the plans. Have the plans and design calculations checked and sealed by a North Carolina Licensed Professional Engineer. If corrections to the drawings are necessary, submit 1 set of corrected reproducible drawings. Use a plan sheet size of 22" x 34". The drawings become part of the plans.

Design the prestressed concrete panels in accordance with the following criteria:

(a) Design details to provide a mating surface joint or a draft not exceeding 1/8" resulting in a joint that is closed at the top and a maximum of 1/4" open at bottom of panel. Detail the joints filled with grout or other methods approved by the Engineer to prevent leakage of the concrete. Place a chamfer or fillet, with a 3/4" horizontal width, along the top edges of the panel parallel with the prestressed girder.

(b) Design panels to support the dead load of the panel, reinforcement, plastic concrete and a 50 pounds per square foot construction load. Design the panel and slab acting compositely to support design live loads and dead loads acting on the composite section. Include in the design dead load acting on the composite section an additional load of 20 pounds per square foot for a future asphalt wearing surface. For bridges up to 44 feet in width distribute equally to all deck panels superimposed dead loads for such permanent bridge items as barrier rails, medians or any dead load which is applied after the deck is cast. In the case of bridges over 44 feet wide, distribute these loads equally to the first 2 1/2 panels adjacent to each side of the load.

(c) The design span of the prestressed concrete panel is the clear distance between edges of girders plus 2" measured parallel to the panel edges.

(d) Limit tension in the precompressed tensile zone to 424 psi unless the plans require 0-psi tension.

(2) Fabricated Metal Stay-In-Place Forms

Furnish metal stay-in-place forms with closed tapered ends to form the concrete deck slabs as shown on the plans. Submit 8 copies of complete fabrication and erection drawings for review, comments and acceptance. When required by the design plans, detail SIP forms with excluder plates to exclude concrete from the valleys in the forms. Styrofoam void fillers may be used in SIP metal forms with the following stipulations:

Adhesive shall be used on all three contacting sides of the styrofoam void fillers rather than on the bottom only.

The adhesive shall be compatible with the styrofoam material so as not to cause the styrofoam to decompose.

Duct tape shall not be used to hold the styrofoam in place.

Styrofoam shall be placed in one piece across each bay, and be trimmed so as not to extend over the girder.

Styrofoam damaged during placement of reinforcing steel shall be replaced.

Indicate on these plans the grade of steel, the physical and section properties for all permanent steel bridge deck form sheets and a clear indication of locations of form supports. Do not fabricate the forming material until drawings are accepted.
Design metal stay-in-place forms in accordance with the following criteria:

(a) Accommodate the dead load of the form, reinforcement and the plastic concrete, including the additional weight of concrete due to the deflection of the metal forms, plus 50 pounds per square foot for construction loads. Do not allow the unit working stress in the steel sheet to exceed 72.5% of the specified minimum yield strength of the material furnished nor 36 ksi.

(b) Limit the horizontal leg of the support angle to 3". Design the support angle as a cantilever.

(c) Limit the deflection under the weight of the forms, the plastic concrete and reinforcement to 1/180 of the form span or 1/2" whichever is less; however, do not design for a total loading less than 120 pounds per square foot.

(d) Base the permissible form camber on the actual dead load condition. Do not use camber to compensate for deflection in excess of the foregoing limits.

(e) The design span of the form sheets is the clear distance between edges of beam or girder flanges minus 2 " measured parallel to the form flutes. Design and provide form sheets with a length at least the design span of the forms.

(f) Compute physical design properties in accordance with requirements of the American Iron and Steel Institute “Specification for the Design of Cold-Formed Steel Structural Members” latest published edition.

(g) Provide a minimum concrete cover of 1 1/4" clear above metal stay-inplace form to the bottom mat of reinforcement.

(h) Maintain the plan dimensions of both layers of primary deck reinforcement from the top of the concrete deck.

(i) Do not weld to flanges in tension or to structural steel bridge elements fabricated from non-weldable grades of steel.

(j) Weld metal stay-in-place forms for prestressed concrete girders to embedded clips in the girder flanges. The embedded clips shall be a minimum of 2” x 3” and 2” long. The clips shall be galvanized, 12 gauge ASTM A653 steel and have a ¾” or 1” diameter hole in the 2” leg. The spacing of the clips shall be 12”. All submitted metal stayin-place form designs shall be able to utilize the standard size and spacing of the clip described above.
Do not unload or handle fabricated metal stay-in-place forming materials in such a manner as to damage or alter the configuration of the forms. Replace

damaged materials at no additional cost to the Department.

Store fabricated metal stay-in-place forms that are stored at the project site at least 4" above the ground on platforms, skids or other suitable supports and protect against corrosion and damage from any source.

Install all forms in accordance with detailed fabrication plans submitted to the Engineer for review. Clearly indicate on the fabrication plans the locations where the forms are supported by steel beam flanges subject to tensile stresses. Do not weld to the flanges within these locations. Do not allow form sheets to rest directly on the top of the beam or girder. Securely fasten sheets to form supports with a minimum bearing length of 1" at each end. Center sheets between the form supports. Place form supports in direct contact with the flange of girder or beam. Make all attachments by permissible welds, bolts, clips or other approved means. Weld in accordance with Article 1072-20 of the *Standard Specifications*, except 1/8" fillet welds are permitted.

In the areas where the form sheets lap, securely fasten the form sheets to one another by screws at a maximum spacing of 18". Securely attach the ends of the form sheets to support angles with screws at a maximum spacing of 18".

Where the galvanized coating is damaged on any exposed form metal, thoroughly clean, wire brush, then paint with two coats of zinc oxide zinc dust primer, Federal Specification TT-P-64ld, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds is not considered damage and does not require the above repair.

Locate transverse construction joints at the bottom of a flute and field drill 1/4" weep holes at not more than 12" on center along the line of the joint.

Use a saw for all cuts. Do not flame cut forms.

(E) Falsework and Forms Over or Adjacent to Traffic

In addition to the applicable sections in 420-3(A) through 420-3(D), the following requirements apply to falsework and forms including metal stay-in-place forms and precast concrete deck panels erected over vehicular, pedestrian or railroad traffic, or vessel traffic on navigable waterways. It also covers falsework and forms for those parts of a substructure unit constructed within 20 ft. of the edge of a travelway or railroad track and more than 25 ft. above the ground line at the time of substructure construction.

(1) Submittals

Submit detailed drawings as required by the contract and one set of design calculations for falsework and forms for review and acceptance before beginning construction of the falsework or forms. Have the drawings and design calculations prepared, signed and sealed by a North Carolina Licensed Professional Engineer. These submittal requirements apply to all falsework and form systems covered by this section.

(2) Design

Design falsework and forms for the combined effects of dead load and live load and with appropriate safety factors in accordance with this section and the respective design codes of the materials used. Include the weight of concrete, reinforcing steel, forms and falsework in the dead load. Live load includes the actual weight of any equipment the falsework supports, applied as concentrated loads at the points of contact, and a uniform load of not less than 20 lbs/ft2 applied over the supported area. In addition, apply a line load of 75 lbs/ft along the outside edge of deck overhangs.

(3) Inspection

Before the form or falsework system is loaded, inspect the erected falsework and forms and submit a written statement certifying that the erected falsework system complies with the accepted detailed drawings prepared by the Licensed Professional Engineer. Submit a separate certification for each span, unit, or bridge component. Any condition that does not comply with the accepted drawings, or any other condition deemed unsatisfactory by the Engineer, is cause for rejection until corrections are made.

420-4 PLACING CONCRETE

Do not place concrete until the depth of the excavation, character of the foundation material, adequacy of the forms and falsework, placement of reinforcement and other embedded items are inspected and approved. Do not place concrete without an Inspector present.

Place concrete in daylight or obtain approval for an adequate lighting system for construction and inspection of the work.

In preparation for the placing of concrete, remove all sawdust, chips, and other construction debris and extraneous matter from the interior of forms. Remove hardened concrete and foreign matter from tools, screeds, and conveying equipment.

Make sure that the concrete temperature at the time of placing in the forms is not less than 50° F nor more than 95° F, except where other temperatures are required by Articles 420-7, and 420-14.

Do not use concrete that does not reach its final position in the forms within the time stipulated in Subarticle 1000-4(E).

Thoroughly clean and wet surfaces, other than foundation surfaces, immediately before placing concrete to facilitate bonding to those surfaces.

Regulate the placement of concrete so that the pressures caused by the wet concrete do not exceed those used in the design of the forms.

Thoroughly work the external surface of all concrete during the placing by means of approved tools. During the placing of concrete, take care to use methods of compaction that result in a surface of even texture free from voids, water, or air pockets, and that force the coarse aggregate away from the forms in order to leave a mortar surface.

Place concrete so as to avoid segregation of the materials and the displacement of the reinforcement.

Equip chutes on steep slopes with baffle boards or provide chutes in short lengths that reverse the direction of movement.

Use all chutes, troughs, and pipes made from suitable materials other than aluminum and keep them clean and free from coating of hardened concrete by thoroughly flushing with water after each run. Discharge the water used for flushing clear of the structure.

Confine concrete dropped more than 5 feet by closed chutes or pipes, except in walls of box culverts or retaining walls unless otherwise directed.

Take care to fill each part of the form by depositing the concrete as near to its final position as possible. Work the coarse aggregate back from the forms and around the reinforcement without displacing the bars. After initial set of the concrete, do not jar the forms and do not place strain on the projecting reinforcement or other items embedded in the concrete.

Compact all concrete required to be vibrated by means of approved high frequency internal vibrators or other approved type of vibrators immediately after depositing concrete in the forms. In all cases, have available at least 2 vibrators in good operating condition and 2 sources of power at the site of any structure in which more than 25 cubic yards of concrete is required. Do not attach or hold the vibrators against the forms or the reinforcing steel. When vibrating concrete containing epoxy coated reinforcing steel, use a vibrator with a protective rubber head as approved by the Engineer. Vibrate with care and in such a manner to avoid displacement of reinforcement, ducts, or other embedded elements. Vibrate in the appropriate location, manner, and duration to secure maximum consolidation of the concrete without causing segregation of the mortar and coarse aggregate, and without causing water to flush to the surface. When placing concrete to a depth in excess of 12" and containing one or more horizontal layers of reinforcing steel, place the concrete in horizontal layers not more than 12" thick. Place and compact each layer before the preceding layer takes initial set such that there is no surface of separation between layers.Do not taper layers of concrete in wedge-shaped slopes but instead place them with reasonably square ends and level tops.

If placing additional concrete against hardened concrete, take care to remove all laitance and to roughen the surfaces of the concrete to ensure that fresh concrete is deposited upon sound concrete surfaces and an acceptable bond is obtained. Thoroughly wet the existing concrete for a minimum of 2 hours before placing additional concrete.

Deposit and compact so as to form a compact, dense, impervious concrete of uniform texture which shows smooth faces on exposed surfaces. Repair, remove, and replace in whole or in part as directed and at no additional cost to the Department, any section of concrete found to be porous, cracked, plastered, or otherwise defective.

Protect beams and girders during concreting operations. Remove any concrete that gets on beams or girders immediately by an approved method to restore the surface to the specified condition.

420-5 PUMPING CONCRETE

Placement of concrete by pumping is permitted only when approved. Use and locate suitable pumping equipment that is adequate in capacity for the work and so that no vibrations result which might damage freshly placed concrete. Do not use pumping equipment, including the conduit system, which contains any aluminum or aluminum alloy that comes in contact with the concrete.

Waste all grout used to lubricate the inner surfaces of the conduit system.

Pump so that a continuous stream of concrete without air pockets is delivered.For test purposes, take concrete from the discharge end of the pump.

420-6 SLUMP TESTS

The slump of the concrete is determined in accordance with AASHTO T119.

When a slump test is made and the results of the test exceed the specified maximum, a check test is made immediately from the same batch or truck load of concrete. If the average of the 2 test results exceeds the specified maximum slump, the batch or truck load that contains the batch is rejected.

420-7 PLACING CONCRETE IN COLD WEATHER

(A) General

Do not place concrete when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is below 35°F without permission. When such permission is granted, uniformly heat the aggregates and/or water to a temperature not higher than 150°F. Place the concrete when the temperature of the heated concrete is not less than 55°F and not more than 80°F.

Use aggregates that are free of ice, frost, and frozen particles. Do not place concrete on frozen foundation material.

Protect all concrete by means of heated enclosures or by insulation whenever any of the following conditions occur:

(a) The concrete is placed when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is below 35°F.

(b) The air temperature, measured at the location of the freshly placed concrete in the shade away from artificial heat, is below 35°F and the concrete has not yet attained an age of 72 hours or an age of 48 hours when using high-early strength portland cement concrete. If the mix contains fly ash or ground granulated blast furnace slag, protect the concrete for 7 days.

Provide and place at directed locations a sufficient number of maximum-minimum recording thermometers to provide an accurate record of the temperature surrounding the concrete during the entire protection period.

Assume all risks connected with the placing of concrete under the cold weather conditions referred to herein. Permission given to place concrete when the temperature is below 35°F and the subsequent protection of the concrete as required herein does not relieve the Contractor in any way of the responsibility for obtaining the required results.

(B) Heated Enclosures

Immediately enclose portland cement concrete that is placed when the air temperature is below 35°F, and portland cement concrete that has not yet attained an age of 72 hours before the air temperature falls below 35°F, with a housing consisting of canvas or other approved material supported by an open framework or with an equally satisfactory housing. Maintain the air surrounding the concrete at a temperature of not less than 50°F nor more than 90°F for the remainder of the 72- hour period. Apply these same requirements to high-early-strength portland cement concrete except reduce the 72-hour period to 48 hours. Do not begin these time periods until completing manipulation of each separate mass of concrete.

Provide such heating apparatus as stoves, salamanders, or steam equipment, and the necessary fuel. When using dry heat, provide means of preventing loss of moisture from the concrete.

(C) Insulation

As an alternate to the heated enclosure specified in Subarticle 420-7(B), use insulated forms or insulation meeting all requirements of this subarticle to protect concrete. Use insulation under the same conditions that require heated enclosures. Place the insulation on the concrete as soon as initial set permits.

When using insulation for cold weather protection, batch concrete for sections 12" or less in thickness or diameter as outlined below. Use Type III portland cement without any increase in cement content, or use Type I or II portland cement with the cement content increased to 1.80 barrels per cubic yard. When the mix includes fly ash, use a mix containing 572 lbs. per cubic yard of cement and a minimum of 172 lbs. per cubic yard of fly ash. When the mix includes ground granulated blast furnace slag, use a mix containing 465 lbs. per cubic yard of cement and 250 lbs. per cubic yard of ground granulated blast furnace slag.

Use insulated materials with a minimum thickness of 1". Insulate overhang forms both on the outside vertical faces and on the underside with a 1" minimum thickness of either rigid or blanket type insulation. Use insulating materials which provide a minimum system R value of 4.0 in the up mode as determined by ASTM C-236 with a 15 mph wind over the cold side of the material and a minimum differential of 50°F. Furnish results of tests conducted in accordance with ASTM C-236 by an acceptable commercial testing laboratory for review, comments and acceptance. Obtain such acceptance prior to use of the material. Face or cover insulating blankets, top and bottom, with polyethylene or similar waterproofing material meeting the test requirements of Article 1026-3 except for the length and color requirements. Place blankets on the concrete in such a manner that they form a waterproof surface for the protected concrete. Do not use blankets with rips and tears in the waterproofing material unless acceptably repaired. When the anticipated low temperature expected during the protection period is less than 10°F, provide 2" of insulation. Overlap blanket insulation mats at the edges by at least 6". Tightly butt rigid type insulation sheets together and seal. Take particular care to provide effective protection of curbs, corners, and around protruding reinforcing steel.

Should the air under the insulation fall below 50° F during the protection period, immediately cover the concrete with canvas and framework or other satisfactory housing and apply heat uniformly at a rate such that the air surrounding the concrete is not less than 50° F for the remainder of the protection period.

In the event that insulating materials are removed from the concrete prior to the expiration of the curing period, cure the concrete for the remainder of the period in accordance with Article 420-15.

420-8 CONSTRUCTION JOINTS

Provide construction joints only where located on the plans or shown in the placing schedule, unless otherwise approved in writing.

Place the concrete in each integral part of the structure continuously. Do not commence work on any such part unless the concrete supply, forces, and equipment are sufficient to complete the part without interruption in the placing of the concrete.

In case of emergency, make construction joints or remove the concrete as directed.

Make construction joints without keys, except when required on the plans. Rough float surfaces of fresh concrete at horizontal construction joints sufficiently to thoroughly consolidate the concrete at the surface.

After placing concrete to the construction joint and before placing fresh concrete, thoroughly clean the entire surface of horizontal construction joints of surface laitance, curing compound, and other materials foreign to the concrete. Clean vertical construction joints of curing compound and other materials foreign to the concrete.
Thoroughly clean and wet concrete surfaces for a minimum of 2 hours before placing additional concrete in order to facilitate bonding.

420-9 WIDENING EXISTING STRUCTURES

Where plans call for widening existing concrete structures, or otherwise require bonding new concrete to old, remove portions of the existing structures as indicated on the plans.

When extending an existing culvert, remove the following portions of the existing culvert: the portions that interfere with the proposed extension, headwalls only as necessary to clear proposed subgrade by a minimum of 18", and wingwalls in such a manner that square surfaces the full thickness of the new sidewalls are provided for bonding new concrete to old. Cut existing wingwall reinforcing steel off flush with the concrete surface.

Thoroughly roughen, clean of loose material, and wet connecting surfaces of the old concrete for a minimum of 2 hours before placing new concrete.

420-10 EXPANSION JOINTS

(A) General

Locate and construct all joints as shown on the plans.

Chamfer or edge the edges of joints as shown on the plans or as directed.

Immediately after removing the forms, inspect the expansion joint carefully. Neatly remove any concrete or mortar in the joint.

(B) Filled Joints

Use cork, bituminous fiber, neoprene, or rubber meeting the requirements of Article 1028-1 in all expansion joint material. Use an optional second layer to obtain the required thickness, when a thickness of more than 1" is required.

Cut the joint filler to the same shape and size as the area to be covered except cut it 1/2" below any surface that is exposed to view in the finished work. As an option, cut the joint filler the same size and shape as that of the adjoining surfaces, and neatly cut back the material 1/2" on the surfaces that are exposed to view after the concrete hardens. Cut the joint filler out of as few pieces as practicable and, except as noted above, completely fill the space provided. Fasten the pieces in any one joint together in an approved manner. Do not use loose fitting or open joints between sections of filler or between filler and forms. Do not use joints made up with small strips. Place two-ply roofing felt over all joints in the filler material in vertical expansion joints below top of curbs. Place the felt on the side of the joint adjacent to the new pour.

Seal all expansion joints with a low modulus silicone sealant in accordance with Article 1028-4.

420-11 DRAINS IN WALLS AND CULVERTS

Construct drain holes and weep holes in abutment walls, wing walls, retaining walls, and the exterior walls of culverts as shown on the plans unless otherwise directed, and backfill in accordance with the requirements of Articles 410-8 and 410-9.

Cover drain holes and weep holes at the back face of the wall with hardware cloth of commercial quality, approximately No. 4 mesh, of aluminum or galvanized steel wire.

420-12 ANCHOR BOLTS AND BEARING AREAS

(A) Anchor Bolts

Accurately set all necessary anchor bolts in piers, abutments, or pedestals either while placing concrete, in formed holes, or in holes cored or drilled after the concrete sets.

If set in the concrete, position the bolts by means of templates and rigidly hold in position while placing the concrete.

Form holes by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves, or other approved devices, and withdrawing them after the concrete partially sets. Provide holes formed in this manner that are at least 4" in diameter.

Core holes at least 1" larger in diameter than the bolt used. Use approved equipment for coring concrete. Do not use impact tools. Place reinforcing steel to provide adequate space to core bolt holes without cutting the reinforcing steel.

During freezing conditions, protect anchor bolt holes from water accumulation at all times.

Bond the anchors with a non-shrink portland cement grout or a grout made with epoxy resin. Completely fill the holes with grout. Use any pre-approved non-shrink composition compatible with the concrete.

(B) Bearing Areas

Finish bridge seat bearing areas to a true level plane to not vary perceptibly from a straightedge placed in any direction across the area.

Place bearing plates in accordance with the requirements of Article 440-4.

420-13 ADHESIVELY ANCHORED ANCHOR BOLTS OR DOWELS

(A) Description

The work covered by this section consists of furnishing all necessary labor, equipment, and materials and performing all operations necessary for installing anchor bolts/dowels in concrete using an adhesive bonding system in accordance with the details shown on the plans and with the requirements of Section 1082 unless otherwise directed.

Submit a description of the proposed adhesive bonding system to the Engineer for review, comments and acceptance. Include in the description the bolt type and its deformations, equipment, manufacturer’s recommended hole diameter, embedment depth, material specifications, and any other material, equipment or procedure not covered by the contract.

List the properties of the adhesive, including density, minimum and maximum temperature application, setting time, shelf life, pot life, shear strength and compressive strength. If bars/dowels containing a corrosion protective coating are required, provide an adhesive that does not contain any chemical elements that are detrimental to the coating and include a statement to this effect in the submittal concerning the contents as required by State or Federal Laws and Regulations.

(B) Procedure

(1) Drilling of Holes into Concrete

When directed, use a jig or fixture to ensure the holes are positioned and aligned correctly during the drilling process. Upon approval, adjusting hole locations to avoid reinforcing steel is permitted.

Drill the holes with a pneumatic drill unless another drilling method is approved. Follow the manufacturer's recommendations regarding the diameter of the drilled hole.

Immediately after completion of drilling, blow all dust and debris out of the holes with oil-free compressed air using a wand extending to the bottom of the hole. Remove all dust from the sides of the holes by brushing the holes with a stiff-bristled brush of a sufficient size and then blow the hole free of dust. Repeat this procedure until the hole is completely clean. Check each hole with a depth gauge to ensure proper embedment depth.

Repair spalled or otherwise damaged concrete using approved methods.

(2) Inspection of Holes

Inspect each hole immediately prior to placing the adhesive and the anchor bolts/dowels. Ensure all holes are dry and free of dust, dirt, oil, and grease. Rework any hole that does not meet the requirements of the contract.

(3) Mixing of Adhesive
Mix the adhesive in strict conformance with the manufacturer's instructions.

(4) Embedment of Anchor Bolt/Dowel
Clean each anchor bolt/dowel so that it is free of all rust, grease, oil, and other contaminants.

Unless otherwise shown on the plans, the minimum anchor bolt/dowel embedment depth is such that the adhesive develops at least 125% of the anchor bolt/dowel yield load as determined by the manufacturer.

Insert the anchor bolt/dowel the specified depth into the hole and slightly agitate it to ensure wetting and complete encapsulation. After insertion of the anchor bolt/dowel, strike off any excessive adhesive flush with the concrete face. Should the adhesive fail to fill the hole, add additional adhesive to the hole to allow a flush strike-off. Do not disturb the anchor bolts/dowels while adhesive is hardening.

(C) Field Testing

When specified on the plans, test the installed anchor bolts/dowels for adequate adhesive as specified below. Inform the Engineer when the tests will be performed at least 2 days prior to testing. Conduct the tests in the presence of the Engineer.

Use a calibrated hydraulic centerhole jack system for testing. Place the jack on a plate washer that has a hole at least 1/8" larger than the hole drilled into the concrete. Position the plate washer on center to allow an unobstructed pull. Position the anchor bolts/dowels and the jack on the same axis. Have an approved testing agency calibrate the jack within 6 months prior to testing. Supply the Engineer with a certificate of calibration.

In the presence of the Engineer, field test 10% of the first 50 anchor bolts/dowels prior to installing any additional anchors. For testing, apply and hold briefly 90% of the anchor bolt/dowel yield load shown on the plans. No visible signs of movement of the anchor bolts/dowels is permitted under this load. Upon receiving satisfactory results from these tests, install the remaining anchors. Test a minimum of 2% of the remaining anchors as previously described.

Record data for each anchor bolt/dowel tested on the report form entitled Installation Test Report of Adhesively Anchored Anchor Bolts or Dowels. Obtain this form from the North Carolina Department of Transportation Materials and Tests Engineer. Submit a copy of the completed report forms to the Engineer.

Final acceptance of the adhesively anchored system is based on the conformance of the pull test to the requirements of this specification. Failure to meet the criteria of this specification is grounds for rejection.

420-14 PLACING AND FINISHING BRIDGE DECKS

(A) Placing Concrete

Unless otherwise noted on the plans, use Class AA cast-in-place concrete conforming to the requirements of Section 1000.

When noted on the plans, use sand lightweight concrete conforming to the requirements of Section 1000.

Place concrete in accordance with these Specifications. Properly vibrate concrete to avoid honeycomb and voids. Have pouring sequences, procedures and mixes approved by the Engineer.

For metal stay-in-place forms, do not place concrete on the forms to a depth greater than 12" above the top of the forms. Do not drop concrete more than 3 feet above the top of the forms, beams or girder. Keep the top surface of prestressed concrete panels clean. Thoroughly inspect panels prior to placement of the concrete cast-in-place slab. Remove any foreign matter, oil, grease or other contaminants either with a high pressure water blast or sand blast. Saturate the top surface of the prestressed concrete panels by thoroughly wetting the top surface with water for a minimum of 2 hours before placing the cast-in-place concrete slab. Do not allow the wetted panel surface to dry before cast-in-place concrete slab placement. Remove all puddles and ponds of water from the surface of the panels and top of girder flanges before placing the cast-in-place concrete slab.

Obtain a smooth riding surface of uniform texture, true to the required grade and cross section, on all bridge decks.

Do not place bridge deck concrete until the Engineer is satisfied that adequate personnel and equipment are present to deliver, place, spread, finish, and cure the concrete within the scheduled time; that experienced finishing machine operators and concrete finishers are employed to finish the deck; and that weather protective equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. During the period between April 15 and October 15, begin placing the bridge deck concrete as early as practical to allow the work to be accomplished during the cooler hours when forms, beams, and reinforcing steel are at ambient air temperatures.

Unless otherwise permitted, set the rate of concrete placement and use a set retarder such that the concrete remains workable until the entire operation of placing, screeding, rescreeding, surface testing, and corrective measures where necessary are complete. Use of a set retarder is waived when conditions clearly indicate it is not needed.

Place concrete in the deck when the concrete temperature at the time of placement is not less than 50° F, nor more than 90° F, except where other temperatures are required by Article 420-7.

Place concrete at a minimum rate of 35 cubic yards per hour.

Place and firmly secure supports for screeds or finishing machines before beginning placement of concrete. Set supports to elevations necessary to obtain a bridge roadway floor true to the required grade and cross section, and make allowance for anticipated settlement. Use supports of a type that upon installation, no springing or deflection occurs under the weight of the finishing equipment. Locate the supports such that finishing equipment operates without interruption over the entire bridge deck.

Immediately prior to placing bridge deck concrete, check all falsework and make all necessary adjustments. Provide suitable means such as telltales to permit ready measurement by the Engineer of deflection as it occurs. Do not adjust the profile grade-line for any of the forming types used, unless permitted.
On continuous steel beam or girder spans, cast the concrete in the order shown on the plans. Place concrete in a continuous manner between headers. Use approved screeds, screed supports, and screeding methods.

(B) Finishing

Unless otherwise specified or permitted, use mechanically operated longitudinal or transverse screeds for finishing bridge deckconcrete. Do not use vibratory screeds unless specifically approved. Use readily adjustable screeds with sufficient rigidity and width to strike-off the concrete surface at the required grade. Do not use aluminum strike-off elements of screeds and hand tools used for finishing concrete.

Furnish personnel and equipment necessary to verify the screed adjustment and operation prior to beginning concrete placement.

Unless otherwise permitted, do not use longitudinal screeds for pours greater than 85 feet in length. Place sufficient concrete ahead of the screeded area to assure all dead load deflection occurs before final screeding.

When using a transverse screed on a span with a skew angle less than 75 degrees or more than 105 degrees, orient and operate the truss or beam supporting the strike-off mechanism parallel to the skew. Position the strike-off parallel to the centerline of bridge, and make the leading edge of concrete placement parallel to the skew. If approved, operate at a reduced skew angle on very wide or heavily skewed spans where the distance between screed supports exceeds 100 feet.

Orient and operate transverse screeds used on spans with skew angles between 75 degrees and 105 degrees parallel to the skew or perpendicular to the centerline of bridge.

Prior to placing concrete, verify the adjustment and operation of the screed as directed by operating the screed over the entire area and across all end bulkheads. Check the floor thickness and cover over reinforcing steel shown on the plans, and make adjustments as necessary.

During the screeding operation, keep an adequate supply of concrete ahead of the screed and maintain a slight excess immediately in front of the screed. Operate the screed to obtain a substantially uniform surface finish over the entire bridge deck. Do not allow workmen to walk on the concrete after screeding. Use a minimum of 2 approved work bridges to provide adequate access to the work for the purpose of finishing, testing, straightedging, making corrections, fogging, applying curing medium, and for other operations requiring access to the bridge deck Support the work bridges outside the limits of concrete placement.

The Engineer makes random depth checks of deck thickness and cover over reinforcing steel over the entire placement area and directly behind the screed in the fresh concrete. If depth checks indicate variations from plan dimensions in excess of 1/2", take corrective action immediately.

Immediately following the screed and while the concrete is still workable, test the floor surface for irregularities with a 10-foot straightedge. Test by holding the straightedge in successive positions parallel to the centerline of bridge and in contact with the floor surface. Test the surface approximately 18" from the curb line, at the centerline of each lane, and at the centerline of 2 lane bridges. Advance along the bridge in stages of not more than 1/2 the length of straightedge. Test the surface transversely at the ends, quarter points, and center of the span as well as other locations as directed.

Immediately correct areas showing depressions or high spots of more than 1/8" in 10 feet by filling depressions with fresh concrete or by striking off high spots. Make corrections with hand tools or a combination of hand tools and rescreeding. Do not use the straightedge as a finishing tool. Give surfaces adjacent to expansion joints special attention to assure they meet the required smoothness.

Provide on the site fogging equipment which is capable of applying water to the concrete in the form of a fine fog mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the bridge deck resulting from wind, high temperature, or low humidity, or a combination of these factors. Do not apply the moisture from the nozzle under pressure directly upon the concrete and do not allow it to accumulate on the surface in a quantity sufficient to cause a flow or wash the surface. Maintain responsibility for determining when to apply the fog mist; however, also apply it when directed.

Keep readily available on site an adequate supply of suitable coverings that will protect the surface of the freshly placed bridge deck from rain. After the water sheen disappears from the surface and before the concrete becomes non-plastic, finish the surface of the floor further by burlap dragging, fine bristle brooming, belting, or other acceptable method which produces an acceptable uniform texture.

Do not use membrane curing compound unless approved. Cure the concrete using the water method in accordance with Article 420-15(B), with the following exceptions. Prior to reaching initial set, place a curing medium consisting of burlap under polyethylene sheets or another approved material on the deck and keep moist for a minimum of 7 curing days. Wet the burlap or other approved curing medium prior to placing on the deck. Apply water to the curing medium through soaker hoses or another approved method. Apply water in amounts to keep the medium moist but do not allow the water to flow or pond on the deck.

After curing the concrete, test the finished surface by means of an approved rolling straightedge designed, constructed, and adjusted to accurately indicate or mark all floor areas which deviate from a plane surface by more than 1/8" in 10 feet. Remove all high areas in the hardened surface in excess of 1/8" in 10 feet with an approved grinding or cutting machine. Where variations are such that the corrections will extend below the limits of the top layer of grout, seal the corrected surface with an approved sealing agent as required. If approved, correct low areas in an acceptable manner. Produce corrected areas that have a rough, uniform texture and present neat patterns. In all cases, maintain a minimum of 2" of concrete cover over reinforcement.

Unless otherwise indicated on the plans, groove bridge decks Produce grooves that are perpendicular to the centerline of bridge. Do not start grooving until final straightedging and, when necessary, acceptable corrective measures are complete. Cut grooves into the hardened concrete using a mechanical saw device, which leaves rectangular grooves 1/8" wide and 3/16" deep. Produce grooves that have a center to center spacing of 3/4". Do not groove the deck surface within 18" of the gutter lines and 2" of expansion joints or elastomeric concrete in expansion joint blockouts. On skewed bridges, ungrooved triangular areas adjacent to the joint are permitted, provided the distance from the centerline joint to the nearest groove, as measured parallel to the centerline of roadway, does not exceed 18". Between expansion joints on horizontally curved bridges, periodically adjust the grooving operation such that adjacent grooves are separated by no more than 3" along the outer radius of the bridgedeck.

Continuously remove all slurry or other residue resulting from the grooving operation from the bridge deck by vacuum pick-up or other approved methods. Prevent slurry from flowing into deck drains or onto the ground or body of water under the bridge. Dispose of all residue off the project.

(C) Inspection

The Engineer observes all phases of the construction of the bridge deck slab. These phases include installation of the metal forms; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete
placement and vibration; and finishing of the bridge deck.
After the deck concrete is in place for a minimum period of 2 days, test the concrete for soundness and bonding of the metal stay-in-place forms by sounding with a hammer as directed. For a minimum of 50% of the individual form panels, as selected by the Engineer, hammer test over the entire area of the panel. If areas of doubtful soundness are disclosed by this procedure, remove the forms from such areas for visual inspection after the pour attains a minimum compressive strength of 2400 psi.Remove the stay-in-place forms at no additional cost to the Department.

At locations where sections of the forms are removed, do not replace the forms, but repair the adjacent metal forms and supports to present a neat appearance and assure their satisfactory retention. As soon as the forms are removed, allow the Engineer to examine for cavities, honeycombing and other defects. If irregularities are found, and in the opinion of the Engineer these irregularities do not justify rejection of the work, repair the concrete as directed. If the concrete where the forms are removed is unsatisfactory, remove additional forms, as necessary, to inspect and repair the slab. Modify the methods of construction as required to obtain satisfactory concrete in the slabs. Remove and repair all unsatisfactory concrete as directed.

Provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures.

420-15 CURING CONCRETE

(A) General

Unless otherwise specified in the contract, use any of the following methods except for membrane curing compounds on bridge deck unless permitted in conjunction with the polyethylene sheeting method or on concrete which is to receive epoxy protective coating in accordance with 420-18. Advise the Engineer in advance of the proposed method. Have all material, equipment, and labor necessary to promptly apply the curing on the site before placing any concrete. Cure all patches in accordance with this article. Improperly cured concrete is considered defective.

When used in this article, curing temperature is defined as the atmospheric temperature taken in the shade away from artificial heat, with the exception that it is the temperature surrounding the concrete where the concrete is protected in accordance with Article 420-7.

A curing day is defined as any consecutive 24-hour period, beginning when the manipulation of each separate mass is complete, during which the air temperature adjacent to the mass does not fall below 40° F.

After placing the concrete, cure it for a period of 7 full curing days.

Take all reasonable precautions to prevent plastic shrinkage cracking of the concrete, including the provision of wind screens, fogging, application of an approved temporary liquid moisture barrier, or the early application of temporary wet coverings to minimize moisture loss.

Repair, remove, or replace as directed concrete containing plastic shrinkage cracks at no cost to the Department.

(B) Water Method

Keep the concrete continuously wet by the application of water for a minimum period of 7 curing days after placing the concrete.

When using cotton mats, rugs, carpets, or earth or sand blankets to retain the moisture, keep the entire surface of the concrete damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. Do not apply the moisture from the nozzle under pressure directly upon the concrete and do not allow it to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period, clear the concrete surfaces of all curing mediums.

(C) Membrane Curing Compound Method

Spray the entire surface of the concrete uniformly with a wax-free, resin-base curing compound conforming to the requirements of Article 1026-2. Use clear curing compound to which a fugitive dye is added for color contrast on bridge superstructures and substructures, and on retaining walls. Use either white pigmented or clear curing compound on culverts.

Apply the membrane curing compound after the surface finishing is complete, and immediately after the free surface moisture disappears. During the finishing period, protect the concrete by applying water with the fogging equipment specified in Subarticle 420-15(B).

Seal the surface with a single uniform coating of the specified type of curing compound applied at the rate of coverage recommended by the manufacturer or as directed, but not less than 1 gallon per 150 square feet of area on surfaces other than bridge approach slabs. On bridge approach slabs, apply the curing compound at a minimum rate of 1 gallon per 100 square feet of area.

At the time of use, thoroughly mix the compound with the pigment uniformly dispersed throughout the vehicle. If the application of the compound does not result in satisfactory coverage, stop the method and begin water curing, as set out above, until the cause of the defective work is corrected.

At locations where the coating shows discontinuities, pinholes, or other defects, or if rain falls on the newly coated surface before the film dries sufficiently to resist damage, apply an additional coat of the compound at the same rate specified herein immediately after the rain stops.

Completely remove any curing compound adhering to a surface to which new concrete is to be bonded by sandblasting, steel wire brushes, bush hammers, or other approved means.

Protect the concrete surfaces to which the compound is applied from abrasion or other damage that results in perforation of the membrane film for 7 curing days after placing the concrete. If the film of membrane compound is damaged or removed before the expiration of 7 curing days, immediately cure the exposed concrete by the water method until the expiration of the 7 curing days or until applying additional curing compound.

In the event that the application of curing compound is delayed, immediately start applying water as provided in Subarticle 420-15(B) and continue until resuming or starting application of the compound.

(D) Polyethylene Sheeting Method

Wet the exposed finished surface of concrete with water, using a nozzle that so atomizes the flow to form a mist and not a spray, until the concrete sets, after which place the white opaque polyethylene sheeting. Continue curing for 7 curing days after the concrete is placed. If the sheeting is damaged or removed before the expiration of 7 curing days, immediately cure the exposed concrete by the water method until placing additional sheeting or until after 7 curing days.

Use sheeting which provides a complete continuous cover of the entire concrete surface. Lap the sheets a minimum of 12" and securely weigh down or cement them together in such a manner as to provide a waterproof joint.

If any portion of the sheets is broken or damaged before the expiration of the curing period, immediately repair the broken or damaged portions with new sheets properly secured in place.

Do not use sections of sheeting damaged to such an extent as to render them unfit for curing the concrete.

(E) Forms-in-Place Method

As an option, cure surfaces of concrete by retaining the forms in place for a minimum period of 7 curing days after placing the concrete.

If electing to leave forms in place for a part of the curing period and using one of the other methods of curing included in this article for the remainder of the curing period, keep the concrete surfaces wet during transition between curing methods.

420-16 REMOVAL OF FORMS AND FALSEWORK

Do not remove forms and falsework for the portions of structures listed in Table 420-1 until the concrete attains the compressive strength shown, as evidenced by nondestructive test methods approved in writing or by conducting compressive strength tests in accordance with AASHTO T22 and T23. Furnish approved equipment used for nondestructive tests.

TABLE 420-1
MINIMUM CONCRETE STRENGTH FOR
REMOVAL OF FORMS AND FALSEWORK

Portion of Structure	Minimum Compressive Strength, psi
Bridge Deck Slabs and overhangs for beam and girder bridges	3,000
Arch culverts, top slabs of box culverts, walls of box culverts when cast monolithically with the top slab or when the wall is 10 feet or more in height, caps and struts of sub-Structures, diaphragms, and other members subject to dead load bending	2,400

Remove forms for ornamental work, railing, parapets, walls less than 10 feet in height, curb faces on bridge superstructures, and vertical surfaces that do not carry loads, any time after 3 hours if the concrete is set sufficiently to permit form removal without damage to the member.
Do not remove forms used for insulation before the expiration of the minimum protective period required in Article 420-7.

Do not remove formwork for bent diaphragms until after casting deck concrete and allowing the concrete to attain a strength of 2,400 psi. As an option, to remove support from bent diaphragms prior to casting deck concrete, submit for approval a method to prevent the possibility of bent diaphragms slipping downward.

When removing forms prior to the end of the required curing period, use other curing methods to complete the required curing. When removing forms from underneath slabs prior to the end of the curing period, complete the curing in accordance with the requirements of Subarticle 420-15(C).

420-17 SURFACE FINISH

(A) General

Finish all concrete as required by this article except for bridge decks. Use the type of finish called for in Subarticles 420-17(B) through 420-17(D), except where the contract requires a Class 1 or Class 2 surface finish. Apply epoxy protective coating as required by 420-18.

(B) Ordinary Surface Finish

Apply ordinary surface finish to all formed concrete surfaces either as a final finish or preparatory to a higher class finish. On surfaces backfilled or otherwise covered, or enclosed surfaces, the removal of fins and form marks, the rubbing of grouted areas to a uniform color, and the removal of stains and discoloration, is not required. Use an ordinary surface finish, unless otherwise required, as final finish on all surfaces.

During the placing of concrete, take care to use methods of compaction that result in a surface of even texture free from voids, water, or air pockets, and that the coarse aggregate is forced away from the forms in order to leave a mortar surface.

Immediately after removing the forms, clean and fill with grout all pockets, depressions, honeycombs and other defects as directed. Remove all form ties or metal spacers to a depth of at least 1" below the surface of the concrete then clean and fill the resulting holes or depressions with grout. As an option, break off flush with the concrete surface those metal devices with exposed cross sectional area not exceeding 0.05 square inches on surfaces permanently in contact with earth fill.
Unless otherwise required, remove fins and other projections flush with the concrete surface. Remove stains and discoloration.

Use grout for patching which contains cement and fine aggregate from the same sources and in the same proportions as used in the concrete. Cure the grout in accordance with Article 420-15. After the grout has thoroughly hardened, rub the surface with a carborundum stone as required to match the texture and color of the adjacent concrete.

(C) Unformed Surfaces Not Subjected to Wear

Finish all unformed surfaces not subjected to wear by placing an excess of material in the forms and removing or striking off such excess with a wooden template, forcing the coarse aggregate below the mortar surface. Do not use mortar topping for concrete railing caps and other surfaces falling under this classification.

Obtain the final finish for caps and railing in one of the following ways:

(1) Brush Finish: After striking off the concrete as described above, have skilled and experienced concrete finishers thoroughly work and float the surface with a wooden, canvas, or cork float. Before this last finish sets, lightly stroke the surface with a fine brush to remove the surface cement film, leaving a fine grained, smooth, but sanded texture.

(2) Float Finish: Finish the surface with a rough carpet float or other suitable device leaving the surface even, but distinctly sandy or pebbled in texture.

(D) Sidewalk, Islands, or Stairways on Bridges

Strike off and compact fresh concrete until a layer of mortar is brought to the surface. Finish the surface to grade and cross section with a float, trowel smooth, and finish with a broom. If water is necessary, apply it to the surface immediately in advance of brooming. Broom transverse to the line of traffic.

(E) Class 1 Surface Finish

In addition to the requirements of Subarticle 420-18(B), as soon as the pointing sets sufficiently to permit, thoroughly wet the entire surface with a brush and rub with a coarse carborundum stone or other equally good abrasive, bringing the surface to a paste. Continue rubbing to remove all form marks and projections, producing a smooth dense surface without pits or irregularities.
Carefully spread or brush uniformly over the entire surface the material ground to a paste by rubbing and allowing it to take a reset. After rubbing, cure the surface for a period of 7 curing days. Obtain the final finish by thoroughly rubbing with a fine carborundum stone or other equally good abrasive. Continue this rubbing until the entire surface is of a smooth texture and uniform color.

(F) Class 2 Surface Finish

In addition to the requirements of Subarticle 420-17(B), after the pointing sets sufficiently to permit, thoroughly wet and rub the entire surface with a coarse carborundum stone or other equally good abrasive to bring the surface to a smooth texture and remove all form marks. Finish the paste formed by rubbing as described above by carefully stroking with a clean brush, or spread it uniformly over the surface and allow it to take a "reset", then finish it by floating with a canvas, carpetfaced, or cork float; or rub down with dry burlap.

420-18 EPOXY COATING

(A) General

Use an epoxy coating meeting the requirements of Section 1081, Type 4A Flexible and moisture insensitive. Provide a certification showing the proposed epoxy meets Type 4A requirements.

(B) Surfaces

With the exception of cored slab bridges, apply the epoxy protective coating to the top surface area, including chamfer area of bent caps under expansion joints and of end bent caps, excluding areas under elastomeric bearings. For cored slab bridges, do not apply the epoxy protective coating to the bent or end bent caps.

Use extreme care to keep the area under the elastomeric bearings free of the epoxy protective coating. Do not apply the epoxy protective coating in the notch at the ends of the prestressed concrete girders.

Thoroughly clean all dust, dirt, grease, oil, laitance and other objectionable material from the concrete surfaces to be coated. Air blast all surfaces immediately prior to applying the protective coating.

Use only cleaning agents preapproved by the Engineer.

(C) Application

Apply epoxy protective coating only when the air temperature is at least 40°F and rising, but less than 95°F and the surface temperature of the area to be coated is at least 40°F. Remove any excess or free standing water from the surfaces before applying the coating. Apply one coat of epoxy protective coating at a rate such that it covers between 100 and 200 ft^2/gal.

Under certain combinations of circumstances, the cured epoxy protective coating may develop an oily condition on the surface due to amine blush. This condition is not detrimental to the applied system.

Apply the coating so that the entire designated surface of the concrete is covered and all pores are filled. To provide a uniform appearance, use the exact same material on all visible surfaces.

420-19 PROTECTION OF SUBSTRUCTURE CONCRETE FROM RUST STAINS

In order to prevent unpainted structural steel from staining substructure concrete, protect all final exposed areas of the concrete from rust stains until casting the bridge deck and sealing the expansion joints. Use an approved method for protecting the concrete. In lieu of the above, remove the stains by approved methods and cleaning agents.

420-20 PLACING LOAD ON STRUCTURE MEMBERS

Do not place beams or girders on concrete substructures until the concrete in the substructure develops a minimum compressive strength of 2,400 psi.

In addition to the requirements of Article 410-8, do not place backfill or fill for retaining walls, abutments, piers, wing walls, or other structures that will retain material to an elevation higher on one side than the other until the concrete develops the minimum specified strength for the class of concrete required for the structure.

Do not carry backfill for arch culverts and box culverts to an elevation higher than 1 foot above the top of footing or bottom slab until the concrete develops the minimum specified strength for the class of concrete required for the culvert.

Adhere to the following time and strength requirements for erection of forms and construction of superimposed bridge substructure elements:

(A) Wait a minimum of 12 hours between placing footing or drilled pier concrete and erecting column forms.

(B) Wait a minimum of 24 hours between placing footing or drilled pier concrete and placing column concrete.

(C) Wait a minimum of 72 hours between placing column concrete and beginning erection of cap forms or until column concrete attains a compressive strength of at least 1,500 psi.

(D) Wait a minimum of 96 hours between placing column concrete and placing cap concrete or until column concrete attains a compressive strength of at least 2,000 psi.

Do not place vehicles or construction equipment on a bridge deck until the deck concrete develops the minimum specified 28 day compressive strength and attains an age of at least 14 curing days. Construction equipment is allowed on bridge approach slabs after the slab concrete develops a compressive strength of at least 3,000 psi and attains an age of at least 7 curing days. A curing day is defined in Subarticle 420-15(A).

Provide evidence that the minimum compressive strengths referred to above are satisfied by nondestructive test methods approved in writing or by compressive strength tests made in accordance with AASHTO T22 and T23. Furnish approved equipment for use in nondestructive tests.

Do not place construction equipment, materials, or other construction loads on any part of the structure without permission. Submit 7 copies of the proposed plans for placing construction loads on the structure for review, comments and acceptance.

Do not abruptly start or stop concrete trucks on bridge deck. Do not mix concrete in the truck while on the deck. While machine forming concrete barrier rail or parapet, do not place any equipment on the deck except one concrete truck and the equipment necessary to place the concrete. Allow concrete barrier rail and parapet to attain a compressive strength of 3000 psi prior to placing any traffic on the deck other than equipment referenced above necessary to construct any remaining barrier rail or parapet. Do not operate heavy equipment over any box culvert until properly backfilling with a minimum cover of 3 feet.

420-21 MEASUREMENT AND PAYMENT

Class __________Concrete will be measured and paid as the number of cubic yards of each class that is incorporated into the completed and accepted structure except as indicated below. The number of cubic yards of concrete is computed from the dimensions shown on the plans or from revised dimensions authorized by the Engineer. When the foundation material is rock, the number of cubic yards of footing concrete is computed by the average end area method using the lower limits established for foundation excavation. The volume of concrete displaced by piles other than steel piles is not included in the quantity to be paid for.

Grooving bridge floors will be measured and be paid as the actual number of square feet shown on the plans. Where the plans are revised, the quantity to be paid for is the quantity shown on the revised plans.

Reinforced Concrete Deck Slab and Reinforced Concrete Deck Slab (sand lightweight concrete) will be measured and paid as the number of square feet shown on the plans. No separate payment will be made for furnishing and incorporating calcium nitrite corrosion inhibitor when required by the plans.

The plan quantity is determined from the horizontal surface area using the nominal dimensions and configuration shown in the Layout Sketch for computing surface area as shown on the plans. The transverse dimension is out to out of slab including raised median and/or sidewalk sections. Diaphragms are considered as a portion of the slab. When required by the plans, curtain walls, raised medians, sidewalks, pavement brackets, end posts, sign mounts, luminaire brackets and any other concrete appurtenances, expansion joint material, etc. are also considered a part of this item. Concrete Barrier Rail (including curved end blocks for the concrete barrier rail, when used) is not considered a part of this item.

For structural steel spans, the quantities of concrete and reinforcing steel shown on the plans are based on a metal stay-in-place forming method. These quantities include amounts for 1" additional concrete due to the corrugation of the metal forms, concrete diaphragms and, when required by the plans, curtain walls, pavement brackets, end posts, raised medians, sidewalks and other required attachments based on the profile grade and plan camber of the girders.

For prestressed concrete girder spans, the quantities of concrete and reinforcing steel shown on the plans are based on the forming method detailed on the plans. These quantities include concrete diaphragms, and, when required by the plans, curtain walls, pavement brackets, end posts, raised medians, sidewalks, and other required attachments based on the profile grade and plan camber of girders. The quantities also include either cast-in-place slab concrete when the plans are detailed for the prestressed concrete panel forming method or amounts for 1" additional concrete due to the corrugation of the metal forms when the plans are detailed for the fabricated metal stay-in-place form forming method and based on the profile grade and plan camber of the girders.

No measurement is made for concrete or reinforcing steel due to a variation in camber of the girders from the plan camber or for additional quantities required by optional methods of forming.

No separate measurement or payment will be made for furnishing, installing, and testing anchor bolts/dowels. Payment at the contract unit prices for the various pay items will be full compensation for all materials, equipment, tools, labor, and incidentals necessary to complete the work.

These prices and payments will be full compensation for all items required to construct concrete structures.

Payment will be made under:

Pay Item	Pay Unit
Class _____Concrete	Cubic Yard
Grooving Bridge Floors	Square Foot
Reinforced Concrete Deck Slab	Square Foot
Reinforced Concrete Deck Slab (Sand Lightweight Concrete)	Square Foot

DIVISION 10
MATERIALS

SECTION 1000
PORTLAND CEMENT CONCRETE
PRODUCTION AND DELIVERY

1000-1 DESCRIPTION

This section addresses portland cement concrete to be used for pavement, precast construction, incidental construction, and structures. Produce and deliver portland cement concrete to where it is incorporated into the work.

Produce portland cement concrete composed of portland cement, fine and coarse aggregates, water, and, optionally, a pozzolan. Type IP blended cement or Type IS blended cement may be used in lieu of portland cement, and fly ash, ground granulated blast furnace slag, or silica fume may be substituted for a portion of the portland cement. In addition, add an air entraining agent and/or other chemical admixtures if required or permitted by these Specifications. Use the class of portland cement concrete required by the contract, and proportion, mix, and deliver in accordance with the requirements contained herein.

Mixes for all portland cement concrete covered by this section shall be designed by a Certified Concrete Mix Design Technician.

When concrete being placed in any one pour is furnished by more than one concrete plant, use the same mix design for all concrete, including sources of cement, sand, stone, pozzolan, and all admixtures.

1000-2 MATERIALS

Refer to Division 10:

Item	Section
Coarse Aggregate	1014-2
Fine Aggregate	1014-1
Portland Cement	1024-1
Type IP Blended Cement	1024-1
Fly Ash	1024-5
Type IS Blended Cement	1024-1
Ground Granulated Blast Furnace Slag	1024-6
Silica Fume	1024-7

Water	1024-4
Air Entraining Agent	1024-3
Chemical Admixtures	1024-3
Calcium Nitrite Corrosion Inhibitor	1024-3

1000-3 PORTLAND CEMENT CONCRETE FOR CONCRETE PAVEMENT

(A) Composition and Design

Submit concrete paving mix design in terms of saturated surface dry weights on M&T Form 312U for approval a minimum of 30 days prior to proposed use.

Use a mix that contains a minimum of 526 pounds of cement per cubic yard, a maximum water cement ratio of 0.559, an air content in the range of 4.5 to 5.5 percent, a maximum slump of 1.5" and a minimum flexural strength of 650 psi at 28 days.

The cement content of the mix design may be reduced by a maximum of 20% and replaced with fly ash at a minimum rate of 1.2 pounds of fly ash to each pound of cement replaced. Use a maximum water-cementitious material ratio not to exceed 0.538.

The cement content of the mix design may be reduced by a maximum of 50% and replaced with blast furnace slag pound for pound.

Include in the mix design the source of aggregates, cement, fly ash, slag, and admixtures; the gradation and specific gravity of the aggregates; the fineness modulus (F.M.) of the fine aggregate; and the dry rodded unit weight and size of the coarse aggregate. Submit test results showing that the mix design conforms to the criteria, including the 28-day flexural strength of a minimum of 6 beams made and tested in accordance with AASHTO T126 and AASHTO T97. Design the mix to produce an average flexural strength sufficient to indicate that a minimum strength of 650 psi will be achieved in the field.

Where concrete with a higher slump for hand methods of placing and finishing is necessary, submit an adjusted mix to provide a maximum slump of 3" and to maintain the water-cementitious material ratio established by the original mix design.

(B) Air Entrainment

Entrain air in the concrete by the use of an approved air entraining agent dispensed with the mixing water, unless prohibited.

Provide an air content of 5.0 percent plus or minus 1.5 percent in the freshly mixed concrete. The air content will be determined in accordance with AASHTO T152, T121, or T196. At the option of the Engineer, the air content may be measured by the Chace indicator, AASHTO T199, in which case sufficient tests will be made in accordance with AASHTO T152, T121, or T196 to establish correlation with the Chace indicator. Concrete will not be rejected based on tests made in accordance with AASHTO T199.

(C) Slump

Provide concrete with a maximum slump of 1½" where placed by a fully mechanized paving train and a maximum of 3" where placed by hand methods.

The sample taken for determination of slump will be obtained immediately after the concrete has been discharged onto the road.

(D) Set Retarding Admixture

With permission, the Contractor may use an approved set retarding admixture to facilitate placing and finishing.

Use a quantity of set retarding admixture within the range shown on the current list of approved admixtures maintained by the Materials and Tests Unit.

(E) Water Reducing Admixtures

With permission, the Contractor may use an approved water reducing admixture to facilitate placing and finishing.

Use a quantity of water reducing admixture within the range shown on the current list of approved admixtures maintained by the Materials and Tests Unit.

(F) Contractor's Responsibility for Process Control

Control the materials and operations to produce uniform pavement that meets specification requirements. Submit a plan detailing the process control and the type and frequency of testing and inspection necessary to produce concrete that meets the Specifications. Submit this plan at the preconstruction conference. Perform sampling, testing, and inspection necessary to provide adequate process control. During all batching and delivery operations assign a Certified Concrete Batch Technician on site whose sole duty is to supervise the production and control of the concrete. This duty includes the following:

(1) Tests and inspections necessary to maintain the stockpiles of aggregates in an unsegregated and uncontaminated condition.

(2) Calibration of admixture dispensing systems, weighing systems, and water gages.

(3) Tests and adjustments of mix proportions for moisture content of aggregates.

(4) Mixer performance tests prior to reducing mixing time of central mix plant to less than 90 seconds and at other times when deemed necessary by the Engineer.

(5) Verifying the actual mixing time of the concrete after all materials are introduced into the mixer at the beginning of paving operations and at least once each month.

(6) Testing all vibrators.

(7) Tests necessary to document the slump and air content of the mix produced. Determine air content at least twice each day.

(8) Tests for depth of the pavement in the plastic state.

(9) Furnishing data to verify that the approved theoretical cement content has been met at intervals not to exceed 50,000 square yards of pavement.

(10) Signing all plant reports, batch tickets, and delivery tickets.

The Department certifies technicians who satisfactorily complete examinations prepared and administered by the Division of Highways.

Perform all test procedures in compliance with the appropriate articles of Section 1000.

Tests may be witnessed by the Engineer. Document the results of all tests and inspections and make a copy available to the Engineer upon request. Take prompt action to correct conditions that have resulted in or could result in the submission of materials, products, or completed construction that do not conform to the requirements of the Specifications.

(G) Contractor Not Relieved of Responsibility for End Result

The Contractor will not be relieved of his obligation to produce a uniform pavement meeting Specifications by reason of:

(1) The acceptance or approval by the Engineer of the concrete mix design or any adjustments;

(2) Compliance with the concrete mix design and compliance with the testing requirements and other process control requirements by the Contractor; or

(3) The failure of the Engineer to perform any tests in the process control, nor the performance of any tests in the process control that indicate compliance with the Specifications.

1000-4 PORTLAND CEMENT CONCRETE FOR STRUCTURES AND INCIDENTAL CONSTRUCTION

(A) Composition and Design

Provide the class of concrete required by the contract.

Submit proposed concrete mix designs for each class of concrete to be used in the work. Mix proportions shall be determined by a testing laboratory approved by the Department. Base mix designs on laboratory trial batches that meet the requirements of Table 1000-1 and other applicable sections of these Specifications. Determine quantities of fine and coarse aggregate by ACI 211, *Recommended Practice for Selecting Proportions for Normal Weight Concrete*, using the absolute volume basis.

Submit mix designs in terms of saturated surface dry weights on M&T Form 312U at least 35 days prior to proposed use. Adjust batch proportions to compensate for surface moisture contained in the aggregates at the time of batching. Changes in the saturated surface dry mix proportions will not be permitted unless revised mix designs have been submitted to the Engineer and approved.

Accompany M&T Form 312U with a listing of laboratory test results of aggregate gradation, air content, slump, and compressive strength. List the compressive strength of at least three 6" x 12" or 4" x 8" cylinders at the age of 7 and 28 days.

Perform laboratory tests in accordance with the following test procedures:

Aggregate Gradation	AASHTO T27
Air Content	AASHTO T152
Slump	AASHTO T119
Compressive Strength	AASHTO T23 and T22

The Engineer will review the mix design for compliance with the Specifications and notify the Contractor as to its acceptability. Do not use a mix until written notice has been received. Acceptance of the mix design does not relieve the Contractor of his responsibility to furnish a product that meets Specifications. Upon written request from the

Contractor, a mix design accepted and used satisfactorily on any Department project may be accepted for use on other projects.

(B) Air Entrainment

Entrain air in the concrete unless otherwise indicated on the plans or in the Specifications. Add an air entraining agent at the time of mixing to produce an air content in the freshly mixed concrete of 6.0 percent plus or minus 1.5 percent when tested at the job site. Determine the air content in accordance with AASHTO T152, T196, or T121. Measurement of air content may also be performed by the Chace indicator in accordance with AASHTO T199, in which case sufficient tests will be made in accordance with AASHTO T152, T121 or T196 to establish correlation with the Chace indicator. Concrete for structures will not be rejected based on tests made in accordance with AASHTO T199. Concrete for incidental construction may be rejected based on an average of 3 or more tests made in accordance with AASHTO T199.

Air entraining agent may be added at the job site when permitted by the Engineer.

(C) Strength of Concrete

The compressive strength of the concrete will be considered the average compressive strength test results of two 6" x 12" cylinders, or two 4" x 8" cylinders if the aggregate size is not larger than size 57 or 57M. Make cylinders in accordance with AASHTO T23 from the concrete delivered to the work. Make cylinders at such frequencies as the Engineer may determine and cure them in accordance with AASHTO T23 as modified by the Department. Copies of these modified test procedures are available upon request from the Materials and Tests Unit.

Table 1000-1

Requirements For Concrete

Class of Concrete	Minimum compressive strength at 28 days, psi	Maximum Water-Cement Ratio				Consistency Max. Slump, Inches		Min. Cement Content, Lbs/Yd^3	
		Air-Entrained Concrete		Non Air-Entrained Concrete		Vibrated	Non-Vibrated	Vibrated	Non-Vibrated
		Rounded Aggregate	Angular Aggregate	Rounded Aggregate	Angular Aggregate				
AA	4500	0.381	0.426	---	---	3.5	---	639 - 715	---
AA Slip Form	4500	0.381	0.426	---	---	1.5	---	639 - 715	---
Drilled Pier	4500	---	---	0.450	0.450	---	5 - 7 dry 7 - 9 wet	---	640 - 800
A	3000	0.488	0.532	0.550	0.594	3.5	4	564	602
B	2500	0.488	0.567	0.559	0.630	2.5	4	508	545
B Slip Formed	2500	0.488	0.567	---	---	1.5	---	508	---
Sand Lightweight	4500	---	0.420	---	---	4	---	715	---
Latex Modified	3000 (7day)	0.400	0.400	---	---	6	---	658	---
Flowable Fill excavatable	150 (max. @ 56 days)	as needed	as needed	as needed	as needed	---	flowable	---	40
Flowable Fill non-excavatable	125	as needed	as needed	as needed	as needed	---	flowable	---	100
Pavement	650 (flexural)	0.559	0.559	---	---	1.5 slip form 3.0 hand placed		526	---
Precast	See Table 1077-1	as needed	as needed	---	---	8	as needed	as needed	as needed
Prestress -6000	6000 or less	0.450	0.450	---	---	8		564	---
Prestress +6000	greater than 6000	0.400	0.400	---	---	8		564	---

When the average compressive strength of the concrete test cylinders is less than the minimum strength specified in Table 1000-1 and the Engineer determines it is within reasonably close conformity with strength requirements, concrete strength will be considered acceptable. When the Engineer determines average cylinder strength is not within reasonably close conformity with specified strength, the inplace concrete will be tested. Based on these test results, the concrete will either be accepted with no reduction in payment or accepted at a reduced unit price or rejected as set forth in Article 105-3.

(D) Temperature Requirements

The concrete temperature at the time of placing in the forms shall be not less than 50°F nor more than 95°F except where other temperatures are required by Articles 420-8, 420-9 and 420-15.

Do not place concrete without permission when the air temperature measured at the location of the concrete operation in the shade away from artificial heat is below 35°F. When such permission is granted, uniformly heat the aggregates and/or water to a temperature not higher than 150°F. Do not place heated concrete in the forms if the temperature is less than 55°F or more than 80°F.

(E) Elapsed Time for Placing Concrete

Deliver concrete to any monolithic unit of a structure at a rate that will permit proper handling, placing, and finishing of the concrete. Regulate the delivery so that the maximum interval between the placing of batches at the work site does not exceed 20 minutes.

Place concrete before the time between adding the mixing water to the mix and placing the concrete in the forms does not exceed that set forth in Table 1000-2.

(F) Use of Set Retarding Admixtures

Use an approved set retarding admixture in all concrete placed in the superstructure of bridges such that the concrete will remain workable until the entire operation of placing and finishing, including corrective measures, if necessary, has been completed. The Engineer may waive the use of set retarding admixture when conditions clearly indicate that it is not needed.

TABLE 1000-2
ELAPSED TIME FOR PLACING CONCRETE

Air or Concrete Temperature Whichever is Higher	Maximum Elapsed Time No Retarding Admixture Used	Retarding Admixture Used
90°F or above	30 minutes	1 hr. 15 minutes
80°F through 89°F	45 minutes	1 hr. 30 minutes
*79°F or below	60 minutes	1 hr. 45 minutes
**70°F through 79°F	60 minutes	1 hr. 45 minutes
**69°F or below	1 hr. 30 minutes	2 hr. 15 minutes

* Applicable to Class AA and A concrete.
** Applicable to Class B concrete.

Other structural concrete may also contain an approved set retarding admixture when permitted by the Engineer.

Use a quantity of set retarding admixture within the range shown on the current list of approved admixtures issued by the Materials and Tests Unit.

(G) Use of Water Reducing Admixtures

By permission of the Engineer, the Contractor may use an approved water reducing admixture to facilitate placing and finishing.

Use a quantity of water reducing admixture within the range shown on the current list of approved admixtures issued by the Materials and Tests Unit.

(H) Use of Calcium Chloride

Calcium chloride may be used as a set accelerating agent where permitted by the Engineer. Use 1 lb. of calcium chloride per 100 lb. of cement except where lesser amounts are directed. Do not use calcium chloride where steel reinforcement, metal conduit, or other metals will be in contact with the concrete. Do not use calcium chloride in concrete that has a temperature higher than 70°F, or when the air temperature is greater than 70°F. Provide cold weather protection for concrete containing calcium chloride in the same manner as is provided for concrete without calcium chloride.

Use calcium chloride in liquid form. Use a solution of 1 pound or less of calcium chloride per 1 quart of water, and mix well. To avoid incompatibility with other additives, add the calcium chloride to the batch after all other ingredients have been put into the mixer.

(I) Use of Fly Ash

Unless otherwise specified, fly ash may be substituted for portland cement in all classes of concrete at a rate not to exceed 20% by weight of the required cement noted in Table 1000-1. Unless otherwise specified, substitute at least 1.2 pounds of fly ash per pound of cement replaced. Do not substitute fly ash for a portion of Type IP or IS cement or for portland cement in high early strength concrete.

Use the following table to determine the maximum allowable water-cementitious material (cement + fly ash) ratio for the classes of concrete listed. For all other classes, the maximum water-cementitious material ratio will be the same as the water-cement ratio listed in Table 1000-1.

	Maximum Water-Cementitious Material Ratio	
Class of Concrete	**Rounded Aggregate**	**Angular Aggregate**
AA & AA Slip Form	.366	.410
A	.469	.512
B & B Slip Form	.469	.545
Pavement	.538	.538

(J) Use of Ground Granulated Blast Furnace Slag

Unless otherwise specified, slag may be substituted pound for pound for portland cement in all classes of concrete at a rate not to exceed 50% by weight of the required cement. Do not exceed the water-cement ratio shown in Table 1000-1. Do not substitute slag for a portion of Type IP or IS cement or for portland cement in high early strength concrete.

(K) Use of Calcium Nitrite Corrosion Inhibitor

Units with calcium nitrite in a quantity less than specified are subject to rejection. Furnish concrete cylinders to the Engineer, in a quantity to be specified, to verify the concentrations of calcium nitrite in hardened concrete. Concrete that fails to contain calcium nitrite at the required concentrations as tested is subject to rejection. Use air-entraining, waterreducing, and/or set-controlling admixtures compatible with calcium nitrite solutions. Strictly adhere to the manufacturer's written recommendations regarding the use of admixtures, including storage, transportation and method of mixing. If preferred, use calcium nitrite, which acts as an accelerator, in conjunction with a retarder to control the set of concrete, as per the manufacturer's recommendation. Add an approved calcium nitrite corrosion inhibitor (30% solids) to the concrete mix at the batch plant for the bridge elements identified by the plan notes. Use the inhibitor at a minimum rate of 3.0 gal/yd^3. Ensure that the hardened concrete contains at least 5.1 lbs/yd^3 nitrite (NO_2) when tested in accordance with Materials and Tests Method Chem. C-20. The preceding paragraph does not apply to concrete used in prestressed concrete members. Concrete used in prestressed concrete members shall be tested in accordance with 1078-4(G).

1000-5 CONCRETE FOR MACHINE PLACED CURB, CURB AND GUTTER, AND PAVED DITCH

Use Class B Slip Form.

1000-6 HIGH EARLY STRENGTH PORTLAND CEMENT CONCRETE

Use high early strength portland cement concrete when required by contract. When not required, it may be used at the Contractor's option with approval of the Engineer.

For all classes of concrete, high early strength concrete may be produced by using Type III portland cement. To produce high early strength concrete with regular cement, use a higher class of concrete as follows:

For Class A and Class B, use Class AA with a minimum cement content of 677 pounds per cubic yard; for Class B Slip Form, use Class AA Slip Form with a minimum cement content of 677 pounds per cubic yard. Other classes that lend themselves to high early strength with regular cement will be reviewed by the Engineer on a case-by-case basis.

1000-7 FLOWABLE FILL

Flowable fill consists of portland cement, water, pozzolan and/or fine aggregate, and, optionally, conventional concrete admixtures and/or a high-air entraining agent or foaming agent. Use it for filling underground storage tanks and pipe culverts and for backfilling culverts, bridge substructures, retaining walls, roadway trenches and for other applications where conventional fill material has traditionally been used.

1000-8 LATEX MODIFIED CONCRETE

(A) **Materials** Use materials that meet the requirements for the respective items in the *Standard Specifications* with the following exceptions:

Cement - Do not use Type III (high early strength).

Aggregate – Follow Section 1014 of the *Standard Specifications*, except provide coarse aggregate that meets the gradation for standard size No. 78M.

Fine Aggregate – Follow the *Standard Specifications***.**

Latex Emulsion Admixture – Use a formulated latex admixture that is a non-hazardous, film forming, polymeric emulsion in water and is homogeneous and uniform in composition. Add all stabilizers at the point of manufacture.

Use a latex modifier conforming to the following requirements:

Polymer Type	Styrene Butadiene 68 ±4% Styrene 32 ±4% Butadiene
Average Polymer Particle Size	1500 to 2500 Angstroms
Emulsion Stabilizers	Anionic and non-ionic surfactants
Percent Solids	46.5 to 49.0
Weight per gallon, lbs at 75°F	8.40 to 8.60
pH	9.5 to 11.0
Shelf Life	2 Years
Color.	White

Provide a Type 5 Supplier's Certification for each load of latex emulsion admixture in accordance with Article 106-3 of the *Standard Specifications*. Test admixture samples to verify compliance with the specification requirements before use. Allow 7 days for sampling and testing after delivery to the project.

Do not allow the temperature of latex emulsion admixture to fall below 35°F at any time or exceed 85°F after delivery to the project.

For latex emulsion that has been in storage, use a transfer pump and lines to recirculate it before using.

Latex Modified Concrete – Use a workable mixture that meets the following requirements:

Cement Content, lbs/yd^3	658
Latex Emulsion Admixture, gal/yd^3	24.5
Air Content of Plastic Mix, %	3.5 - 6.5
Slump, inches	3 – 6
% Fine Aggregate as percent of total aggregate by weight	50 – 55
Minimum 7 day compressive strength, psi	3000
Water-Cement Ratio by weight, maximum	0.40

Measure the slump 4 to 5 minutes after discharge from the mixer.

Submit the latex modified concrete mix design, completed by the latex emulsion manufacturer, to the Engineer for review.

(B) **Equipment** Prior to beginning any work, obtain approval for all equipment to be used for deck preparation, mixing, placing, finishing, and curing the latex modified concrete.

Use sandblasting equipment capable of removing all clay, salt deposits, oil and grease deposits and all other foreign matter. Provide traps or separators to remove oil and water from the compressed air. Use traps or separators of adequate size and drain them periodically during operations. For proportioning and mixing, use self-contained, mobile, and continuously mixing equipment that meets the following requirements:

Use a self-propelled mixer that is capable of carrying sufficient unmixed dry, bulk cement, sand, coarse aggregate, latex modifier, and water to produce at least 6 yd^3 of concrete on site.

Use a mixer that is capable of positive measurement of cement introduced into the mix. Use a recording meter that is visible at all times and equipped with a ticket printout to indicate the quantity of cement.

Calibrate the mixers to accurately proportion the specified mix. Prior to placing latex modified concrete, perform calibration and yield tests under the Engineer’s supervision in accordance with the Department’s written instructions. Copies of these written instructions are available from the Materials and Tests Unit. Perform the calibration and yield tests using the material to be used on the project. Recalibrate the mixer after any major maintenance operation, on the mixer, anytime the source of materials changes, or as directed. Furnish all materials and equipment necessary to perform the calibrations and yield tests.

Use a mixer that controls the flow of water and latex emulsion into the mix. Measure the flow rate of water and the latex emulsion with a calibrated flowmeter coordinated with both the cement and aggregate feeding mechanisms and the mixer. Adjust the flow rate, as necessary, to control the slump and ensure that the water-cement ratios are met. In addition to flowmeters, use mixers with accumulative water and latex meters capable of indicating the number of gallons, to the nearest 0.1 gallon, introduced into the mixer. Filter water and latex with a suitable mesh filter before it flows through the accumulative water and latex meters.

Calibrate the mixer to automatically proportion and blend all components of the indicated composition on a continuous or intermittent basis as the finishing operation requires. Provide a mixer that discharges mixed material through a conventional chute and is capable of spraying water over the placement width as it moves ahead to ensure that the surface to be overlaid is wet prior to receiving the modified material.

Mount a tachometer on the unit to indicate the drive shaft speed.

Use adequate hand tools for placing and leveling concrete down to approximately the correct level for striking off with the screed.

Use a finishing machine that meets the approval of the Engineer and the requirements of the contract. Use a self-propelled finishing machine capable of forward and reverse movement under positive control. Use a machine with at least two finishing devices, one that is a vibrating screed and the other either a vibrating screed, oscillating screed, or one or more rotating cylindrical drums 48 inches long or less and operating between 1500 and 2500 vpm. Make certain the finishing machine can finish the surface to within 1 foot of the edges of the area being placed. Raise all screeds when the finishing machine is moving backwards over the screeded surface.

Use screeds with a vibration frequency that is variable between 3,000 and 6,000 vpm with positive controls. Use screeds with a metal covered bottom face not less than 4 inches wide. Provide screeds with positive control of the vertical position.

Use supporting rails for travelling of the finishing machine rigid enough to eliminate deflection from the weight of the machine.

Proportioning and Mixing of Modified Compositions

Meet the following requirements when proportioning and mixing modified materials:

Use mobile continuous mixers that accurately proportion all materials for the specified mixture. Operate the proportioning equipment at the manufacturer's recommended speed verified with the tachometer during calibration and normal operations.

Yield checks and other checks are permitted.

1000-9 MEASURING MATERIALS

(A) Weighing Cement

Measure cement by weight on scales separate from those used for other materials, and in a hopper entirely free and independent of the hoppers used for weighing the aggregates. When the quantity of cement in a batch exceeds 30 percent of the full capacity of the scale, have the quantity of cement as indicated by the scale be within plus or minus 1 percent of the required weight. For smaller batches, have the quantity of cement as indicated by the scale be not less than the required amount or more than 4 percent in excess. Equip all beam type scales with a tare beam.

(B) Weighing Aggregates

Measure aggregates by weight. Base batch weights on saturated surface dry materials and which are the required weights plus the total weight of surface moisture contained in the aggregates. Have the individual aggregates, as weighed, be within plus or minus 2 percent of the required weights.

(C) Water

Measure water by volume or by weight. Have the quantity of water measured be within plus or minus 1 percent of the required amount.

(D) Admixture Dispensing Systems

Provide a separate dispensing system with separate fill and discharge lines for each type of admixture to be used, except that admixtures may be measured and introduced into the mix manually if approval has been obtained. Have each system be capable of measuring, displaying, and discharging the required amount of admixture into the mix. Keep dispensing systems clean and in good operating condition. Use a dispensing system that is either:

(1) Manually operated, self contained; or

(2) Semi automatic or automatic, self contained; or

(3) Interfaced to operate automatically with the concrete batching control panel.

Have the admixture dispenser dispense the required quantity of admixture for each concrete batch within an accuracy of plus or minus 3 percent. Check the accuracy of the dispenser as provided below. Check the accuracy at the point of discharge, or through a bypass valve suitable for obtaining a calibrated sample of admixture and at the volumes normally used for one half mixer capacity and for full mixer capacity. Determine the accuracy at the time of installation, and check daily during the early part of each day's operation.

Include in each system a graduated measuring unit into which the admixture is batched to permit a quick visual check of accuracy prior to its discharge.

Have the measuring unit be clearly graduated and be of sufficient size to hold the maximum anticipated dose for 1 batch. Clearly mark the measuring unit for the type of admixture to be used.

Control the discharge sequence so that an admixture will not be brought into contact with raw cement or another admixture before being diluted through contact with the mixing water in the mixer. Where 2 types of admixtures are being used, do not discharge them into the mix simultaneously. Add the air entraining agent with the first addition of water and add any other chemical admixture with the final addition of water, unless otherwise permitted.

Construct the discharge lines to completely empty after each cycle. Locate the admixture dispensing systems so that the batching plant operator will have a visual verification of the actual quantity of admixture batched.

Use air entraining admixtures in accordance with the manufacturer's recommendations and in such quantity to provide the specified air content in freshly mixed concrete. Use a quantity of set retarding admixture and of water reducing admixture per 100 lb. of cement that is within the range recommended on the current list of approved admixtures issued by the Materials and Tests Unit.

1000-10 BATCHING PLANT

(A) General

Plants located on the Department rights-of-way shall conform to the requirements of Article 107-3.

Have ready mixed concrete plants inspected and approved by the Department before they are used to produce concrete, either paving, structural or incidental, for the project. Have plants meet all the applicable requirements of the Specifications, and in addition have each ready mix plant provide at least 3 acceptable truck mixers or truck agitators available for use. Use trucks that have an identifying number. Plants approved by the Department will be placed on a list of approved plants that will be made available to the Contractor. All plants will be subject to reinspection at intervals selected by the Engineer. Re-approval after each inspection will be contingent on continuing compliance with the Specifications.

(B) Bins and Hoppers

Provide bins with separate compartments for fine aggregates and for each required size of coarse aggregate in the batching plant. Design each compartment to discharge efficiently and freely into the weighing hopper. Provide control so that, as the quantity desired is being approached, the material may be added slowly and shut off with precision. Construct weighing hoppers to eliminate accumulation of tare materials and to discharge fully unless otherwise permitted. Provide a port or other opening for removing an overload of any one of the several materials from the hopper.

(C) Scales

Use either the beam type, load cell type or the springless dial type scales for weighing aggregates and cement. Have the minimum graduation on beam or dial be not more than 0.1 percent of the total capacity of the scale. Methods of weighing, other than beam or springless dial scales, may be approved by the Engineer provided they meet the required weighing tolerances. Have the scales be accurate within 0.5 percent under operating conditions. Make available ten 50 pound test weights at the plant for checking accuracy. Use test weights which meet the US Bureau of Standards requirements for calibrating and testing equipment. Keep all exposed fulcrums, clevises, and similar working parts of scales clean. When beam type scales are used, make provisions for indicating to the operator that the required load in the weighing hopper is being approached. Have the device indicate at least the last 50 pounds of load, and design it to give a positive indication of overload of the scales. During charging of the hopper, have all indicating devices in full view of the operator and provide convenient access to all controls. Have the indicating devices in the immediate vicinity of the operator so that they are easily readable by the operator.

(D) Water Measuring Devices

Use devices for measurement of the water which are readily adjustable and are capable of being set to deliver the required amount and cut off the flow automatically when this amount has been discharged. Under all operating conditions the device shall have accuracy within 1 percent of the quantity of water required for the batch. Arrange the device so that variable pressures in the water supply line will not affect the measurements. Use measuring tanks of adequate capacity to furnish the maximum mixing water required and equip them with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amounts in the tank.

1000-11 MIXERS AND AGITATORS

(A) General

Mixers are defined as equipment to mix concrete and may be stationary or truck mounted. Agitators are defined as equipment used to haul central mixed concrete and may be truck mixers or truck agitators. Provide a metal plate or plates attached to each mixer and agitator in a prominent place on which the manufacturer has plainly marked the mixing speed of the drum or paddles and the maximum capacity of the drum or container in terms of volume of mixed concrete. On truck mixers and agitators, show the manufacturer's recommended agitating and mixing speed of rotation of the mixing drum or blades. Equip stationary mixers with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. Equip truck mixers with counters to verify the number of revolutions of the drum or blades. Actuate the counters at the initial time the drums have reached mixing speed.

Examine mixers and agitators periodically for changes in condition due to accumulation of hard concrete or mortar, wear of blades, or any other condition which decreases mixing efficiency. Mixers are unacceptable when the radial height or other dimension of the blade has worn below 90 percent of the original dimension. This radial height does not include any lips on the blade, and is the height of the blade running perpendicular to the shell of the drum. Where such conditions are found, do not use the units until they are corrected.

Also examine mixers and agitators periodically for general mechanical condition, including water measuring and discharge apparatus, identifying number on trucks, condition of the blades, speed of rotation of the drum, and condition of the drum.

(B) Mixer Capacity

Do not load truck mixers with concrete with more than 63 percent of the gross volume of the drum. Use mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity. Use stationary mixers, when loaded at the manufacturer's guaranteed mixing capacity and the concrete mixed for the prescribed mixing time, capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and discharging the concrete with satisfactory uniformity.

Use at least 20 percent of the rated mixing capacity as the minimum quantity of concrete permitted to be mixed or agitated in any mixer.

(C) Agitator Capacity

Load the agitator to not exceed 80 percent of the gross drum volume and have it be capable of maintaining the concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

(D) Consistency Tests

The Engineer may, from time to time, make slump tests to measure consistency of the concrete. Take individual samples at approximately the 1/5th point, the midpoint, and the 4/5th point of the load, using AASHTO T119. Such tests will be made within 20 minutes of discharge of that portion of the load. If the results vary by more than 1" in slump, do not use the mixer or agitator unless the condition is corrected.

1000-12 MIXING AND DELIVERY

(A) General

Mix and deliver concrete to the site of the work by one of the following methods, except where other methods are approved. Maintain responsibility for controlling the materials and operations as to produce uniform concrete meeting Specifications requirements.

When concrete is being produced for structures and incidental construction in accordance with the requirements of Article 1000-4, have present during all batching operations a Certified Concrete Batch Technician employed by the Contractor or concrete supplier. During batching and delivery, the sole duty of this employee is to supervise the production and control of the concrete. Perform moisture tests, adjust mix proportions of aggregates for free moisture, complete and sign Batch Tickets (M & T Form 903) or approved delivery tickets, and assure quality control of the batching. Delivery tickets will be permitted in lieu of batch tickets (M & T Form 903) provided they have been reviewed and approved by the Materials and Tests Unit. The Division of Highways certifies technicians who satisfactorily complete examinations prepared and administered by the Division of Highways.

(1) Central Mixed Concrete

Concrete that is mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in a truck agitator or in a truck mixer operating at agitating speed or in non agitating equipment approved by the Engineer. Perform mixing within the capacity and at the mixing speeds recommended by the manufacturer.

(2) Transit Mixed Concrete

Concrete that is mixed completely in a truck mixer while at the batching plant, in transit, or at the work site.

(3) Shrink Mixed Concrete

Concrete that is mixed partially in a stationary mixer at a central mixing plant and completed as transit mixed concrete. Place all ingredients for a batch in the stationary mixer and partially mix before any concrete is discharged to the truck mixer, and do not exceed the rated capacity of the equipment for the batch size. The mixing time at the stationary mixer may be reduced to the minimum necessary to intermingle the ingredients, and the mixing completed in the truck mixer. Use the number of mixing revolutions in the truck mixer as specified for transit mixed concrete or reduce as indicated by mixer performance tests.

(B) Mixing Time for Central Mixed Concrete

Mixing time begins when all solid materials are in the mixing compartment and ends when any part of the concrete begins to discharge. In charging the mixer water will enter in advance of cement and aggregate, and have substantially all the water in the drum before one-third of the specified mixing time has elapsed. Count transfer time in multiple drum mixers as part of the mixing time.

Where mixer performance tests are not made, use a minimum mixing time of 90 seconds, providing that blending of materials during charging is achieved to the satisfaction of the Engineer. The minimum mixing time for an individual mixer is that which, as shown by mixer performance tests, will produce concrete meeting the requirements of Table 1000-3, except that the mixing time shall not be less than 50 seconds under any circumstances. Maximum mixing time excluding discharge time is 150 seconds.

Sampling and testing for mixer performance tests will be done as provided below. Charge the mixer to its rated capacity with the materials and proportions to be used in the work and mixed at the recommended mixing speed to the target time. Stop mixing and begin discharging. Two samples of sufficient size to make the required tests will be taken after discharge of approximately 15 and 85 percent of the load.

TABLE 1000-3

REQUIREMENTS FOR UNIFORMITY OF CONCRETE

Tests	Maximum Permissible Difference in Test Samples
Air content, percent by volume of Concrete (AASHTO T152)	1.0%
Slump, inches (AASHTO T119)	1.0"
Coarse aggregate content, portion by weight of each sample retained on the No. 4 sieve, percent (AASHTO M157)	6.0%
Weight per cubic foot (AASHTO T121)	1.0 lb.
Average compressive strength at 7 days, percent of average (AASHTO T22 and T23)	10.0%*

* Tentative approval may be granted pending 7 day compressive strength tests.

Each of the 2 samples of concrete will be separately tested for the properties listed in Table 1000-3. Tests will be conducted in accordance with the test procedures specified in Table 1000-3 or procedures established by the Materials and Tests Unit.

The mixer performance test described above will be performed on a minimum of 2 batches of concrete. For the performance test to be acceptable, have all tests in each batch tested meet the requirements listed above.

The Engineer may recheck mixer performance at any time when in his opinion satisfactory mixing is not being accomplished.

Where satisfactory mixing cannot be accomplished in 90 seconds, the Engineer may increase the mixing time or require that the mixer be repaired or replaced before any further mixing can be done.

(C) Mixing; Truck Mixers and Truck Agitators

When a truck mixer is used for complete mixing, mix each batch of concrete for at least 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as mixing speed, unless otherwise directed by the Engineer. Unless the mixer is equipped with a counter which will distinguish between mixing and agitating speeds, perform the minimum required number of revolutions of the drum at mixing speed as directed, either at the batching plant before the mixer leaves for the work site and/or at the work site before the concrete is discharged. Perform any additional mixing at the speed designated by the manufacturer of the equipment as agitating speed. Put all materials including mixing water in the drum before actuating the revolution counter for determining the number of revolutions of the drum.

When a truck mixer or truck agitator is used to transport concrete that has been completely mixed in a stationary mixer, perform mixing during transport at agitating speed.

Provide concrete, when discharged from truck mixers or truck agitators, of the consistency and workability required for the work. Control the rate of discharge of the plastic concrete from the mixer drum by the speed or rotation of the drum in the discharge direction with the discharge gate fully open. If additional mixing water is necessary to produce the slump necessary for proper placement, perform it only with permission, and rotate the truck mixer drum a minimum of 25 revolutions at mixing speed before discharge of any concrete. Additional mixing water will be allowed only if the maximum specified water content per cubic yard is not exceeded.

(D) Delivery

Use a ticket system for recording the transportation of batches from the proportioning plant to the site of the work. Use tickets furnished by the Engineer and fill it out in accordance with instructions issued by the Engineer. Issue the tickets to the truck operator at the proportioning plant for each load and have them signed by the plant inspector, which will signify that the concrete in the truck has been inspected prior to departure. Have each ticket show the time batching was completed and if transit mixed, the number of revolutions at mixing speed, if any, at the plant. Deliver the tickets to the inspector at the site of the work. Do not use loads which do not carry such tickets and loads which do not arrive in satisfactory condition within the time limits specified in the work.

Hot Weather Concrete

Placing concrete in hot weather concrete requires good planning. High temperature accelerates the hardening of concrete. Unless special precautions are taken, hot weather can negatively affect concrete properties. Examples of potentially detrimental effects of hot weather include:

- Increased Water Demand
- Difficulty in Control of Entrained Air
- Rapid Slump Loss
- Accelerated Set
- Reduced Durability
- Lower Strength

High air temperatures that are typical of hot weather can result in very unfavorable concrete placing conditions when combined with low humidity, and/or high winds. This is especially true in situations where concrete is placed in elements having large exposed surface areas as in the case of exposed concrete slabs.

Construction materials and construction “means and methods” must be also examined, and properly selected, to minimize the impact of hot weather conditions in the quality and durability of concrete structure. The following are examples of materials and methods that, if not properly utilized, can complicate hot weather operations:

- Use of Type III Cement
- Use of Concrete with Higher Cement Contents
- Use of Larger Size Mixers
- Use of Pumping Equipment
- Larger Concrete Pours

Planning for Hot Weather Conditions

In hot weather conditions, mixing water can rapidly evaporate from the concrete mixture during transportation with a corresponding lost of workability. Therefore, maintaining workability of a concrete mixture during hot weather requires careful planning. Concrete producers utilize various procedures to achieve this objective. For example, chemical admixtures (i.e., retarders and water reducers) are typically used to maintain workability in hot weather conditions without the need to change (i.e., increase) the original water content of a concrete mixture. One may think that “adding” water at the site is the “logical” action to restitute mixing water lost due to evaporation during transportation of the concrete mixture. The result can be an undesirable increase in the water/cement ratio because there is no precise method to determine how much mixing water is lost during transportation. Therefore, if water is added to the mixture at the job site, the water/cement ratio could be increased beyond its original design. This in turn, can result in an undesirable decrease of the intended compressive strength.

Water Demand and Increased Temperature

As an illustration, let's assume that we plan to transport a concrete mixture during hot weather conditions, and that no chemical admixtures are used to maintain the workability of the concrete due to water evaporation. Let's also assume that our original concrete mixture was designed for "normal" weather temperatures of about 62 ºF, contained an aggregate having a nominal maximum size of 1.5 inches, and required approximately 33.2 gallons of water to produce a slump of 3 inches. As can be seen in Figure 10, if water is the only tool available to maintain the consistency and workability of this mixture at a temperature of 82 ºF, then we would need an additional 1.6 gallons per cubic yard of mixture to achieve the desired slump. As previously indicated, the amount of water loss to evaporation depends on various factors and conditions (i.e., temperature, relative humidity, wind) including the type and amount of components in the concrete mixture. Furthermore, there is no reliable manner to measure exactly how much water would be lost during hot weather transportation. Therefore, if a decision is made to add the estimated 1.6 gal/cy additional water, the result could be a net increase in the water to cement ratio, which will produce a reduction in the compressive strength. Remember, the three most important factors for curing concrete is time, temperature, and moisture.

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Fig.10- Example to illustrate an expected increase in water demand due to increased ambient temperatures

"Cooling Down" a Concrete Mixture

One method to minimize the potentially detrimental effects of hot weather is to decrease the temperature of the concrete mixture. This can be achieved by keeping the mixture components as cool as possible. The component easiest and most practical to cool is water. Typical water sources for concrete mixtures include wells and city distribution systems. Well water temperature generally remains at around 55°F. In ready mix concrete production, water can be cooled down by the use of chillers or the concrete mix can be cooled by the use of ice. When ice is used as a cooling agent during the mixing process, the ice must be crushed or flaked. Substitution of ice for water must be done on a "pound-per-pound" basis. Note: one gallon of water weighs 8.33 pounds.

Addition of Ice in a Concrete Mixture Example

Example #1: Assume that hot weather conditions exist and that ice will be used to reduce the temperature of a concrete mixture. The original mixture proportions required the use of 200 gallons of metered water in a batch of concrete. The ready mix concrete producer decides to use 250 pounds of ice in each batch of concrete, to lower the temperature of the concrete.

Question: How much metered water will be necessary after the 250 pounds of ice has been added to the batch of concrete?

Solution:

Quantity of Originally Metered Water in Batch (in gals.):	= **200** gallons of water
Quantity of Ice in Batch (in lbs.):	= 250 pounds of ice
Quantity of Ice in Batch (in gals):	= 250 pounds/ 8.33 pounds/gal
	= **30** gallons of water

Therefore, calculation of new metered water in batch:

Qty New Metered Water (gals)	= Qty Originally Metered Water (gals.) – Qty Ice (gals.)
	= **200** gallons (originally metered) - **30** gallons (withheld for ice)
	= 170 gallons (metered for load)

Example #2: Given 29.5 gallons of metered water per cubic yard of concrete. You need 50 pounds of ice per cubic yard to cool mixture.
Question a): How much new metered water is now needed per cubic yard of concrete?
Question b): How much new-metered water is now needed for a 10 cubic yard load?
Solution (class exercise):

SECTION III

NCDOT - M&T POLICIES

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Michael F. Easley
Governor

Lyndo Tippett
Secretary

March 2, 2004

MEMORANDUM TO: Division Engineers

FROM: Cecil L. Jones, PE
State Materials Engineer

SUBJECT: Determining Air Content of Fresh Concrete Containing Marine Limestone and Lightweight Aggregates

Current procedures require the use of a correction factor of 1% when determining the air content of fresh concrete containing marine limestone aggregates with a pressure meter in accordance with AASHTO T 152. In reviewing project records, we discovered inconsistencies in the application of this correction factor. The Materials and Tests Unit also conducted comparisons with several different concrete mixes with different marine limestone sources during last construction season. We found the differences between the pressure meters and the volumetric meters to vary to the extent that the 1% correction factor is not felt to adequately identify’ the correct air content of concrete using these aggregates.

The durability of concrete is dependent to some degree on the air void content of the mixture, exclusive of air that may be inside voids within aggregate particles. For this reason, it is important to make sure that we are not measuring voids within aggregate particles when determining the air content of fresh concrete. AASHTO T 152 states that the pressure method is applicable to concrete made with relatively dense aggregate particles and requires the determination of an aggregate correction factor. Most aggregates in North Carolina are very dense, so this is not a concern. However, marine limestones are more porous and it therefore becomes important to make sure that we are not measuring voids within the aggregate. Because the volumetric method described in AASHTO T 196 does not apply external pressure, it only measures air voids of the mix and it applies to any type aggregate, whether it is dense, cellular or lightweight. It has always been the Department’s policy to use the volumetric method, or “rollometer” as described by T 196 for lightweight concrete.

Based upon the results of our findings, beginning May l, 2004 all concrete mixes produced using lightweight aggregates, including marine limestone, must be tested using the volumetric method. Current sources of marine limestone include Belgrade, Castle Hayne, Clarks, Goretown Mine, Myrtle Beach, New Bern, Onslow and Rocky Point. Current lightweight aggregate sources include Stalite and Solite.

All NCDOT certified concrete field technicians have received training and have demonstrated proficiency using the volumetric meters. The volumetric meters currently being used are much lighter in weight and easier to use than those used in previous years. We have a supply of volumetric meters available and have more on order to supply those offices affected by this change.

Additional meters will be available through our central office in Raleigh. If you are interested in acquiring one or have any questions concerning this new policy please contact Sam Frederick at 919-733-7091. Your local concrete technician can also provide additional training, or assist you in any concrete related matter.

cc: Steve Varnedoe, PE
Steve DeWitt, PE
Ellis Powell, PE
John Emerson, PE
Resident Engineers
District Engineers
Roadway Construction Engineers
Bridge Construction Engineers

NCDOT III (a)

Date: March 2, 2004

Subject: Determining Air Content of Fresh Concrete Containing Marine Limestone and Lightweight Aggregates.

Summary of Changes:

- Use Volumetric Method, or "Roll-o-meter", in accordance to AASHTO T 196 / ASTM C 173
- For Lightweight and Marine Limestone Aggregates

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

EUGENE A. CONTI, JR.
SECRETARY

February 15, 2010

MEMORANDUM TO: Division Engineers

FROM: Christopher A. Peoples, PE
State Materials Engineer

SUBJECT: Making, Storing and Transporting Concrete Cylinders

We continue to see improperly made, stored and cured concrete cylinders delivered to the Materials and Tests' laboratories for acceptance testing of concrete. In order to insure that the concrete being placed on NCDOT projects complies with the Department's specifications, valid sampling and handling processes must be followed. All concrete cylinders must be sampled, prepared and cured in accordance with AASHTO T-23. Whenever AASHTO T-23 is not followed, the concrete cannot be properly tested. This results in an investigation of the concrete member which in turn causes considerable delay and additional costs in the acceptance process.

To re-emphasize the importance of following proper practices, attached are recommended procedures for use of the 4"x8" plastic cylinder molds and the Department's policy regarding improperly made specimens that was first issued on September 9, 2003 by the State Materials Engineer.

Please share this information with all parties involved.

CAP/lj

cc: Jon Nance, PE
Ricky Greene, PE
Ron Hancock, PE
Bridge Construction Engineers
Roadway Construction Engineers
Randy Pace, PE

PROCEDURES FOR USE OF THE 4” X 8” PLASTIC MOLDS

I. Preparing the 4” X 8” plastic molds for reuse.

1. Drill a small hole, approximately 1/8 inch in diameter, in the bottom of mold.

2. Seal the hole on the inside of the cylinder mold with tape to make the cylinder mold water tight.

3. Apply a light coat of lubricant (form oil, CRC, etc.) to the mold interior. This aids in separation of the mold from the concrete cylinder and helps prevent damage to the molds interior surface. Make sure there is no standing oil in the mold before placing any concrete in it.

II. Casting the 4” X 8” cylinders.

Note: A person who is currently certified by the Materials and Tests Unit as a Field Concrete Technician must make all concrete test cylinders.

1. Select and prepare a proper site for preparing the molds and making the test specimens. This location should be as close as possible to where the member is cast but far enough away to protect them from construction activities, vibrations or other disturbances.

2. Select a representative sample of concrete and remix it before making the cylinders. (See Concrete Field Technician Study Guide) For 4" x 8" cylinders only 2 layers are required. The tamping rod shall be a 3/8 inch diameter straight steel rod approximately 18 inches long, having a hemispherical tip. For specimens with a slump of 1" or less use a wooden flat or stake with a 1" x 1" dimension. Fill the cylinder with two layers, rodding each layer 25 times. In the case of 1" slump or less, penetration of the underlying layer is not required.

3. After casting the cylinders, seal them with opaque plastic caps. The initial storage of all cylinders should be in some type of curing box. A 32 quart or larger Igloo cooler works well. Ensure that the curing box and cylinders are level.

4. Protect the cylinders from vibration and other disturbances for the first 24 hours. Keep them in a moist condition at temperature between 60° and 80°F. Moisture can be maintained by simply putting a 1/4 inch of water in the bottom of the cooler.

III. Curing – Cure the cylinders until they are delivered to the laboratory. One or more of the following procedures can control a satisfactory temperature environment during the initial curing of the specimens: Use of ventilation, use of ice, use of thermostatically controlled heating or cooling devices, use of heating methods such as stoves or light bulbs.

IV. Transporting test cylinders to the laboratory.

Recommended procedure: Transport cylinders to the laboratory in the 4” X 8” plastic reusable molds.

a. Deliver the cylinders to the laboratory no later than 3 days (72 hours) after casting.

b. Do not allow the cylinders to roll or fall while transporting them to the laboratory. The Department has purchased cylinder crates that can store a maximum of 8 cylinders at one time. The crates will fit securely inside a 32-quart cooler. These crates are available through your local Section Concrete Technicians or can be picked up at the central laboratory.

c. Identify each cylinder by contract number, sample number, and date made.

V. <u>Removal of Cylinders from the 4” X 8” reusable plastic molds at the laboratory by the Construction Technician.</u>

Remove the cylinders at the laboratory with compressed air. Cylinders must be at least 24 hours old prior to removing them from the mold.

Procedure:

a. Remove the cap, turn the cylinder upside down, and apply air pressure to the hole in the bottom of the cylinder mold. The mold should then rise on the cylinder. If the cylinder cannot be removed from the mold with compressed air, carefully split one side of the mold with the tool provided at the lab.

b. Use a permanent marker to transfer the identification information to the cylinder. This is provide at the laboratory.

c. Laboratory personnel are not responsible for removing molds or marking cylinders.

VI. <u>Reuse of the 4” X 8” plastic molds.</u>

a. Inspect the 4” X 8” plastic mold before and after each use.

b. Check the plastic mold for warping, splitting, and pitting.

c. Discard the mold if it is deformed to the extent that it will not produce an acceptable cylinder.

Policy on Improperly Made, Stored, Handled or Transported Concrete Cylinders

1. Concrete cylinder specimens that do not conform to requirements of AASTHO T-23 will be marked as failing compressive strength requirements.

2. An investigation will be conducted by the local Concrete Technician to determine the cause of the deficiency and the acceptability of the concrete member it represents.

3. If the investigation reveals that the technician was deficient in the making, curing, handling or transportation of the cylinders in an excess of three times, his/her concrete certification will be removed. In order for the technician to become re-certified, he/she must attend the full Concrete Field Technician school

The purpose of this process is to inform all parties involved with the on going problems of unsatisfactory handling and storage of concrete cylinders. It is not intended to remove certifications from trained technician. The methods for making, storage, handling and transporting of cylinders should follow the guidelines stated in AASHTO T-23, a copy of which is attached.

NCDOT III (b)

Date: February 5, 2010

Subject: Making, storing, and transporting concrete cylinders

Summary of Changes:

- Store concrete cylinders in correct initial curing temperature after properly making.
- Transport cylinders in a protective manner to the testing facility.
- Low strength break results will result in an investigation.

STATE OF NORTH CAROLINA

DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

EUGENE A. CONTI, JR.
SECRETARY

January 15, 2010

MEMORANDUM TO: DIVISION ENGINEERS, RESIDENT ENGINEERS, ROADWAY CONSTRUCTION ENGINEERS AND BRIDGE CONSTRUCTION ENGINEERS

Walton I Jones

FROM: Walton I. Jones
Field Concrete Engineer

SUBJECT: Minimum Sampling for Incidental and Structural Concrete

The minimum testing frequencies for Portland cement concrete for structures and incidental construction are the following. All tests must be performed by a certified "Concrete Field Technician" using the most recent AASHTO/ASTM standards. Additional tests may be required if directed by the Engineer.

CLASS AA,A, and B:

AIR CONTENT- CHACE INDICATOR (AASHTO T-l99): Performed on every load.

SLUMP (AASHTO T-119 / ASTM C-143): Performed on the first load, and a random load per 30 cubic yards or fraction thereof. When test specimens are made.

AIR CONTENT – PRESSURE AIR METER (AASHTO T- 152 / ASTM C-231): Performed on the first load, and a random load per 30 cubic yards or fraction thereof. When test specimens are made.

TEMPERATURE (ASTM C-1064): Performed on the first load and when test specimens are made.

TEST SPECIMENS (AASHTO T-23 / ASTM C-31): One set of cylinders per each placement operation per each 100 cubic yards cumulative or fraction thereof for Class AA and A Concrete. One set of cylinders per each 100 cubic yards or fraction thereof for Class B Concrete.

LIGHTWEIGHT:

AIR CONTENT – CHACE INDICATOR (AASHTO T-199): Performed on every load.

SLUMP (AASHTO T-119 / ASTM C-143): Performed on the first load, and a random load per 30 cubic yards or fraction thereof. When test specimens are made.

AIR CONTENT – VOLUMETRIC (AASHTO T-196 / ASTM C-173): Performed on the first load, and a random load per 30 cubic yards or fraction thereof. When test specimens are made.

UNIT WEIGHT (AASHTO T-121 / ASTM C-138): Performed on the first load, and when test specimens are made.

TEMPERATURE (ASTM C-1064): Performed on the first load and when test specimens are made.

TEST SPECIMENS (AASHTO T-23 / ASTM C-31): One set of cylinders per each placement operation per each 100 cubic yards or fraction thereof.

DRILL PIER:

Air content-Chace method (air content not to exceed 7.5%), slump, temperature, and test specimens will be performed on every load.

NCDOT III (c)

Date: January 15, 2010

Subject: Minimum Sampling Frequencies for Incidental and Structural Concrete.

Summary of Changes:

- Minimum sampling frequencies are established for three general categories of concrete:
  a. Class B, A, AA concrete
  b. Lightweight concrete
  c. Drill pier concrete

- Sampling and testing frequencies are defined as a function of:
  a. The number of truck loads in the placement operation
  b. The volume of concrete in the placement operation
  c. The instance when concrete cylinders are prepared

(c.1) Summary Chart

MINIMUM SAMPLING FREQUENCY

Class A, AA Concrete

TEST	BY LOAD?	BY VOLUME?	OTHER?
SLUMP	First Load	Each 30 cy (Randomly)	Cylinders Made
AIR CONTENT (PRESSURE)	First Load	Each 30 cy (Randomly)	Cylinders Made
TEMPERATURE	First Load	N/R	Cylinders Made
TEST SPECIMENS	Each Placement Operation	Each 100 cy (Randomly)	N/A
UNIT WEIGHT	N/R	N/R	N/R
AIR CONTENT (CHACE)	Every Load	N/R	N/R

(c.2) Summary Chart

MINIMUM SAMPLING FREQUENCY

Class B Concrete

TEST	BY LOAD?	BY VOLUME?	OTHER?
SLUMP	First Load	Each 30 cy (Randomly)	Cylinders Made
AIR CONTENT (PRESSURE)	First Load	Each 30 cy (Randomly)	Cylinders Made
TEMPERATURE	First Load	N/R	Cylinders Made
TEST SPECIMENS		Minimum of one per mix, up to 100 cy, then each 100 cy (Randomly)	N/A
UNIT WEIGHT	N/R	N/R	N/R
AIR CONTENT (CHACE)	Every Load	N/R	N/R

(c.3) Summary Chart

MINIMUM SAMPLING FREQUENCY

LIGHTWEIGHT Concrete

TEST	BY LOAD?	BY VOLUME?	OTHER?
SLUMP	First Load	Each 30 cy (Randomly)	Cylinders Made
AIR CONTENT (VOLUMETRIC)	First Load	Each 30 cy (Randomly)	Cylinders Made
TEMPERATURE	First Load	N/R	Cylinders Made
TEST SPECIMENS	Each Placement Operation	Each 100 cy (Randomly)	N/A
UNIT WEIGHT	First Load	N/R	Cylinders Made
AIR CONTENT (CHACE)	Every Load	N/R	N/R

(c.4) Summary Chart

MINIMUM SAMPLING FREQUENCY

DRILL PIER Concrete

TEST	BY LOAD?	BY VOLUME?	OTHER?
SLUMP	Each Load	N/R	N/R
AIR CONTENT (VOLUMETRIC or PRESSURE)	Optional	N/R	N/R
TEMPERATURE	Each Load	N/R	N/R
TEST SPECIMENS	Each Load	N/R	N/R
UNIT WEIGHT	Optional	N/R	N/R
AIR CONTENT (CHACE)	Each Load ≤ 7.5%	N/R	N/R

M&T Policy for Adding Air-Entraining Agents. Revised January 2, 2002

When the air content of Portland cement concrete measured at the discharge within the time limits of Table 1000-2 of the Standard Specifications is below the specified level by more than the allowable tolerance, the manufacturer may use additional air-entraining admixture to bring the concrete to within specification limits if the following conditions are met:

1. The admixture is the same brand and type as that originally introduced at the concrete plant unless otherwise permitted by the Engineer.

2. The admixture, if liquid, is measured into a bucket containing 1 gallon of water. The admixture, if prepackaged powder, is added according to the manufacturer's recommendation.

3. The admixture, if liquid, is thoroughly mixed with the water and the mixture is then directed as far back in the drum as possible while the drum is momentarily stopped.

4. The maximum allowable water-cementitious material ratio of the concrete is not exceeded with the addition of the water-admixture solution.

5. The concrete is then mixed 30 revolutions at mixing speed.

6. A record is kept by project personnel of the brand, type, and quantity of admixture and the quantity of water added. This information must be recorded and clearly noted on the sample card and the batch ticket.

This policy shall apply only to trucks already on the jobsite and enroute. Concrete plant personnel shall adjust admixture proportions in subsequent loads at the plant so that the air content meets specifications.

Air-entraining agent may be added twice per truck on the job site as long as the total time allowed by the specifications between batching and placement has not elapsed. If, after the second addition the concrete fails to meet air content and/or slump specifications, the concrete shall be rejected.

The intent of this policy is to allow for small adjustments at the start-up of batching operations. It does not relieve the producer from the responsibility of producing good quality concrete on a consistent basis. The routine use of these procedures to meet specification requirements may result in the removal from the Departments' Approved List until such time as the ability to consistently produce good quality concrete is demonstrated.

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NCDOT III (d)

Date: January 2, 2002

Subject: Adding Air-entrained Agent (AEA) to Ready-mix Concrete at the Job Site.

Summary of Changes:

Addition of AEA is permitted at the job site to bring concrete to within specifications provide that:

- Admixture is the same brand/type
- Liquid Admixture is diluted in 1 gal of water and directed to the back of drum
- Concrete is mixed, 30 revolutions minimum at mixing speed
- Admixture is added maximum 2 times
- Not to exceed:

  w/c ratio

  time allowed for placement

  - slump

STATE OF NORTH CAROLINA

DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLY
Governor

P.O. BOX 25201, RALEIGH, NC. 27611-5201

LYNDO TIPPETT
Secretary

January 2, 2002

CONCRETE MIX DESIGN NEW NUMBERING SCHEME

Previous mix design identifications have been replaced with a new numbering scheme. The "old" numbering system (2AA-67-43-122) has been replaced due to difficulty distinguishing between two plants using the same aggregates, or between brands of cement and brands of pozzolan. The new numbering scheme incorporates the producer's own mix number and provides immediate identification of concrete class and plant number, supplies codes for air-entrainment and vibration status, and pozzolan use. An example of the new numbering scheme is the following:

1782VO03081BCE

- 178 – The Ready Mix Plant's Certification Number
- 2 – Concrete Class (AA)
- V – Vibrated and Air-entrained
- O – Without Pozzolan
- 03081BC – Producer's Mix Number
- E – English

CONCRETE MIX DESIGN CODES

Class of Concrete

3 = Class AAA
2 = Class AA
R = Class AA, slip-form barrier rail
1 = Class A

B = Class B
M = Class B, curb & gutter machine
D = Drill shaft

S = Class S
T = Pavement
H = High early strength patch mix
F = Flowable fill

P = Prestress
E = Precast
L = Latex modified concrete

Air-Entrainment and Vibration Status

V = Vibrated and air-entrained
N = Non-vibrated and air-entrained
X = Vibrated and non air-entrained
Y = Non-vibrated and non air-entrained

Pozzolan
O = No pozzolan
F = Class F fly ash
C = Class C fly ash
G = Ground granulated blast furnace slag
U = Silica fume

NCDOT III (e)

Date: January 2, 2002

Subject: Concrete Mix Design New Numbering Scheme.

Summary of Changes:

- Replace previous 10 character mixture ID with new 14 character mixture ID

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201, RALEIGH, NC. 27611-5201

MICHAEL F. EASLY
Governor

LYNDO TIPPETT
Secretary

November 15, 2001

Instructions for Submittal and Acceptance of Concrete Mix Designs

The Physical Testing Engineer, head of the Physical Testing Subunit at the Materials and Tests Unit, is responsible for acceptance of concrete mix designs for all construction and maintenance projects. This includes all cast-in-place, prestress, and precast concrete.

According to the Standard Specifications, mix designs for structural concrete shall be submitted to the Engineer 35 days before proposed use and mix designs for concrete paving shall be submitted 30 days before proposed use.

The Physical Testing Engineer uses a computerized database and mix design assignment program to manage acceptance of concrete mix designs. This is part of the DOT's HiCams system.

Acceptance of a concrete mix design is a twofold process. Step one is entry of the mix design into the database. Step two is assignment of a database mix design to a specific project or, in the case of certain prestress and precast mixes, to a specific manufacturing plant for specific items. A mix design must be in the database for it to be assigned to a project or prestress or precast plant.

For database entry, concrete producers must submit directly to the Physical Testing Engineer each mix design on M & T Form 312U, which requires a listing of class of concrete, materials, mix proportions and properties, and accompanying data.

The concrete producer must state his mix design number on each design. Any combination of numbers and/or letters up to eight places is acceptable. Each mix number must be unique within a given plant. This means that when a producer changes a material source, quantity, or property he must assign a different number to the mix and resubmit it for the database. Only admixture quantities are exempt from this requirement. It is understood that admixture quantities may vary in concrete production due to concrete temperature, environmental conditions, presence of other admixtures, etc. (But remember that use of admixtures must be in accordance with the DOT approved list.)

When the mix design is entered in the database, the computer automatically assigns a prefix to the producer's mix design number. This prefix consists of the DOT-assigned plant number (one, two, or three places) and a three-place code to identify the class of concrete, the vibration/air-entrainment status, and the type of pozzolan used in the mix (if any). The computer also assigns a suffix to the producer's mix number – the letter "E" – to designate that the mix proportions are in the English system of measurement. (All mixes are currently in English. We are not issuing mixes in metric.)

With the mix design in the database, it may now be assigned to a project upon request from the contractor. This is step two in the acceptance process. The contractor must complete and sign Form 312U, the mix design request form, and submit it to the

Resident or Maintenance Engineer. Form 312U includes the project number, other administrative data, and a list of producer mix design numbers the contractor wishes to be accepted. The Resident Engineer in turn submits the form to the Physical Testing Engineer for review.

The Physical Testing Engineer retrieves each requested mix design from the database and reviews it for compliance with project specifications. He then assigns each appropriate mix to the project on the HiCams Concrete Mix Contract Assignment screen. Printed copies are sent to the Resident or Maintenance Engineer and other relevant parties.

Anyone with access to HiCams may view the Concrete Mix Contract Assignment screen for any project. (The database is also available for viewing at any time.) However, only the Physical Testing Engineer and Assistant Physical Testing Engineer may enter mixes in the database and assign mixes on the Concrete Mix Contract Assignment screen.

NCDOT III (f)

Date: November 15, 2001

Subject: Submittal and Acceptance of Concrete Mix Designs.

Summary of Changes:

- Anticipation of submittals
  a. Structural concrete: 35 days
  b. Paving: 30 days before intended use

- Use NCDOT form 312 U

STATE OF NORTH CAROLINA

DEPARTMENT OF TRANSPORTATION

JAMES B. HUNT JR. P.O. BOX 25201, RALEIGH, NC. 27611-5201 DAVID McCOY

Governor Secretary

August 29, 2000

MEMORANDUM TO: READY MIXED CONCRETE PRODUCERS, PRECAST PRODUCERS PRESTRESS PRODUCERS AND CONCRETE PIPE PRODUCERS

FROM: Randy K. Pace
Materials Operations Engineer

SUBJECT: Recording batch weight policy

The purpose of this letter is to clarify the Department's policy concerning recording of batch weights at ready mix facilities.

Batch weights must be recorded for each batch of concrete produced for NCDOT work. The batch weights can be computer generated or hand printed, but must be recorded for each batch produced. Batch weights must be kept on file for the life of the project. This information will be reviewed in the case of low cylinder breaks or discrepancies in the physical properties of the fresh concrete. These tickets should indicate the actual amount of each material used in the batching of the concrete. All corrections to the mix for moisture must also be shown.

Any facility found not recording this information or not retaining the information until the end of the project will be removed from the Department's Approved Producer List.

If you have any questions concerning this policy, please contact the Field Operations Engineer.

NCDOT III (g)

Date: August 29, 2000

Subject: Recording Batch Weight.

Summary of Changes:

- Batch weights (indicating the amount of each ingredient) **must** be recorded for each batch of concrete, and records kept for the life of the project.
- Computer generated or manually recorded are valid.
- Records must show any adjustment made to the mixture (including moisture corrections)

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

EUGENE A. CONTI, JR.
SECRETARY

January 20, 2010

To: Ready Mixed Concrete Producers, Precast Producers, Prestress Producers, Concrete Pipe Producers, and Concrete Pavement Producers

Walton I Jones

From: Walton I. Jones
Field Concrete Engineer

Subject: Revision in Concrete Batch School Certification Process

Beginning in January of 2010 the NCDOT Concrete Batch Technician Certification will require completion of two phases. The first part will consist of the normal classroom portion and must be successfully completed to qualify the student for the second part. The second part is on site field evaluation conducted by Materials and Tests representatives at the point of production of concrete. The technician seeking the Concrete Batch Technician will be required to demonstrate the ability to successfully make batch adjustments correctly. The technician will be evaluated on running moisture tests on the coarse and fine aggregates and making proper moisture adjustments correctly to accommodate for the moisture changes. Additionally, the technician must be able to determine batching tolerances and if any corrections are within the specifications during the on site examination. The prerequisite for first time batch school students is the Concrete Field Technician course. Batchers only have to take the Concrete Field Technician course once. If the certified batcher is involved in testing and sampling plastic concrete, the Concrete Field Technician certification would have to remain current.

The classroom portion will consist of two days of instruction, with the exam given on the second day. Topics covered will include concrete specifications, batch weight adjustments, NCDOT batching policies, falsification issues and ethics policies. The exam will be a closed book exam. A minimum of 80% must be scored on the written test to pass the classroom portion. The classroom portion must be successfully completed before the on site field certification process begins. The concrete producer will be required to assign each batcher to a specific plant when registering the technician for the class. This is only for coordination efforts in arranging for the batch technician performance evaluation. The Department understands that batchers may move from one plant to another as needed. The plant listed on the registration form will be our first contact point to coordinate the onsite evaluation.

Once the classroom portion is successfully completed, students who have never held a Concrete Batch Certification will be evaluated by the Materials and Tests representative at the plant within three months of completion of the classroom portion. During the evaluation, the student will demonstrate the ability to batch concrete based on a NCDOT mix design. The student will also have to make the correct moisture adjustments to the mix based on moisture tests run by the student. When the evaluation is successfully completed, the student will be issued a certification. Only the students assigned to a particular plant will be assessed.

Students who hold a current Concrete Batch Technician certification or whose certification has expired in the last 12 months will be able to batch concrete up until the time of the annual plant certification process. In this case the evaluation process will be conducted along with the plant inspection process. The student must pass the evaluation process to retain certification.

In the future, Concrete Batch Technicians will be evaluated yearly during the annual plant certification. To remain certified, the batchers must successfully complete the field plant evaluation and must be assigned as a batcher at a designated plant. Once the batcher is certified, the classroom portion is good for five years. After the five year cycle, the classroom portion has to be repeated.

wij

cc: Chris Peoples, PE
Randy Pace, PE
Sam Fredericks
Section Materials Specialists
Concrete Technicians

NCDOT III (h)

Date: January 20, 2010

Subject: Revision in Batch School Certification Process

Summary of Changes:

- Each batcher must be assigned to a specific plant when registering for class
- Batcher will be evaluated on site at their concrete plant. Tasks must be completed successfully for certification.
- Concrete Batch Technicians will be evaluated annually.

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

July 11, 2008

Dear Ready Mix Concrete Producers,

The Department has performed several low cylinder investigations in the last couple of months. During these investigations it was found that quite a *few* producers are using a hatching process called "Central Dispatching" to control the concrete production within a company. The purpose of this letter is to clarify the Department's requirement *for* concrete hatching and to reinforce the correct hatching procedures.

The process of centralized dispatching of concrete is allowable if correct batching procedures are followed. Specifically, the order for concrete can be routed through a central dispatching facility; however, the actual control of the concrete mix must be performed at the batching location. Each plant location must have a certified batcher in direct control of the batching operation. Additionally, the signed copy of the approved mix design must be on hand and used during the batching process. Each ready mix concrete company has its own identifier for the mix being used. But the official mix. design form must be used during the batching operations to verify that the mix being - batched is what is approved for that job. Several incidents have occurred where the wrong ingredients were used because the batcher did not verify the source of materials on the approved mix design.

Another concern the Department has is that it appears that some producers are using the approval to conduct central dispatching operations as approval to perform central batching. It was found that on several investigations that the certified batcher at the batch plant could not perform corrections to the mix proportions because the computer system was preset with the information that was entered into the computer. This violates the Departments batching requirements. Each batcher has the responsibility to perform mix proportion adjustments base on the actual material properties on hand and the current weather conditions. Any adjustments to the approved mix design during the batching operations must be performed in person by the certified batcher. An adjustment made to the mix by any other person is a violation to this policy.

It was also found during these investigations that the actual batch weights were not available at the batch plant for the Department to review. Therefore, In order to facilitate the investigation process, each batch plant must maintain the batch weights onsite for 60 days before they can be moved to an off site storage location. If the batch weights are stored in an electronic format in a database, then the batch facility must have access to the database from the batch plant.

A final area of concern for the Department was the seemingly high occurrence of material verification prior to and during the batching process. It is the responsibility of each plant to verify the quality of raw materials being used in the production of ready mix concrete. In several incidents it was found that neither the plant manager nor the batch technician was verifying the materials being used. For example, one plant was batching concrete specifying one brand of cement but was actually utilizing another. When asked about the incident, it was determined that no one had verified the Bill of Lading nor the delivery ticket to assure it was the correct brand of cement. In another investigation, an approved mix design required the use of#67 stone. Historically, this plant always stockpiled and used #57 stone. The certified batcher did not review the mix design prior to or during the batching operation and the incorrect stone was used. In several cases it was found that the certified batcher was not performing moisture checks on the aggregates. It is a requirement that moisture checks be performed before batching operations begin and repeated whenever moisture conditions change. Prior to batching concrete, a moisture determination must be performed on both the coarse and fine aggregates being used that day. A moisture probe may be used for determining the moisture content of the fine aggregate after the initial moisture content has been verified by the standard method and the two moisture contents are within one half a percent of each other. If weather conditions change throughout the day, then additional moisture content verifications will be required. In addition, the certified batcher must have the capabilities to adjust the mix proportions based on changes in moisture.

Any plants not meeting the requirements outlined above will be removed from the Department's Approved Producer List.

If you have any questions concerning this matter please contact Sam Frederick at (919) 733-7091 or at sifrederick@ncdot.gov.

rkp

Sincerely,

Randy K Pace

Randy K. Pace, **PE**
State Materials Operations Engineer

NCDOT III (i)

Date: July 11, 2008

Subject: Central Dispatching

Summary of Changes:

- Certified Batcher must be on site and in direct control of batching operation.
- Mix Design form 312U must be used during batching operation.
- Materials and sources used in concrete should be verified.

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

EUGENE A. CONTI, JR.
SECRETARY

February 18, 2010

MEMORANDUM TO: Division Construction Engineers

FROM: Christopher A. Peoples, PE
State Materials Engineer

SUBJECT: Approval of Volumetric Batching of Concrete

- After several meetings with representatives from the contracting industry, concrete producers, Central Construction Unit, and the Materials and Tests Unit, approval to allow the use of volumetric concrete batching trucks on Departmental projects has been granted. This approval is limited to Class B concrete only and has a volume total of 30 yards per truck per day.

Attached are specifications for the use of volumetric batching trucks. Their use can begin immediately if the company has completed the approval process. The current requirements for concrete mix design approval, batch technician certifications and approved batch plant still apply. In this case, the approved batch plant is truck mounted.

A new facility type, “Volumetric Concrete Truck,” has been created in the Vendor system to handle the approved producer list requirements. Companies will be added to this new category once they have submitted their process control plans for maintaining and calibrating the batch trucks. Additionally, they must submit a Quality Control plan outlining the handling of raw materials, technician training and certifications and truck calibration certificates. Each approved volumetric truck will be listed in the Vendor system.

We hope this approval will allow the contractor and the Department more flexibility in completing the necessary work on our projects.

If you have any questions, please contact Randy Pace at 919-733-7091.

CAP/rkp

Attachment

cc: Jon Nance, PE
Ricky Greene, Jr., PE
Ron Hancock, PE
Dan Holderman, PE
Division Engineers
Resident Engineers
Donnie Thorne
Jack Cowsert, PE
Randy Pace, PE
Sam Frederick
Walton Jones
Section Materials Specialists
Section Concrete Technicians
Bill Arent, CRMCA
Don Brown, Stewart Engineering

NCDOT III (j)

Date: February 18, 2010

Subject: Approval of Volumetric Batching for Concrete

Summary of Changes:

- Volumetric concrete mixers are allowed to place Class B concrete on NCDOT projects
- Process control plan must be approved and each mixer inspected and calibrated
- Limited to 30 cubic yards of concrete per mixer per day

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

PAT MCCRORY
GOVERNOR

ANTHONY J. TATA
SECRETARY

Process Control Plan for Volumetric Concrete Mixers
rev March 13, 2013

A process control plan must be submitted and approved for Volumetric Batching of concrete, with the exception of latex concrete used in an overlay. The process control plan is project specific, and should contain project or contract number, the Resident Engineer or Maintenance Engineer's name, the project location, and the structure in which concrete is to be placed. A copy of the Concrete Mix Design submitted should be included with the process control plan. Also, state the location of the materials storage, and the date concrete placement is scheduled to begin.

All contractor or producers certified personnel involved in the Volumetric Batching operation should be listed, with certification type, number, and expiration date. Please note that while Concrete Field Tech certification is not required to batch concrete, a certified Concrete Field Technician answerable to the contractor or producer should be present at all Volumetric Batching operations on a NCDOT project. The Concrete Field Technician, as well as the Certified Batch Technician, should also be present during the calibration process.

Outlined in the process control plan must be the procedure to be followed during the calibration process by the contractor or producer. Details listed should be the location of the appropriate flow meters for the various components, the order of components to be calibrated, the worksheet to be used, if different from the NCDOT worksheet, and the quality control of the stockpiled material. The process control plan should also detail the checking of the yield, air and slump. Methods of adjusting air and slump should also be addressed.

In the process control plan, detail after calibration the frequency of testing and the type testing to be conducted by the contractor or producer to ensure calibration is correct and air and slump are acceptable. List all quality control procedures to be done to ensure consistent moistures, including handling of stockpile materials and new materials delivered to the storage site.

Finally the process control plan should include the record keeping system to be maintained by the contractor or producer on the materials used, moisture tests run, and calibrations run due to changing moistures or other causes.

Send the process control plan to Walton Jones at wijones@ncdot.gov. Please note the process control plan must be approved before the calibration process and plant inspection (volumetric mixers) is conducted.

If you have any questions or concerns, contact me via email or by phone at 919-715-1746.

wij

Walton Jones, Field Concrete Engineer

NCDOT III (k)

Date: March 13, 2013

Subject: Process Control Plans for Volumetric Concrete Mixers

Summary of Changes:

- The requirements for the process control plan are outlined.

ETHICS

Ethics is defined as a set of rules or standards governing the conduct of a person or the members of a profession. Ethics denotes the theory of right action and the greater good, while morals indicate their practice. Personal ethics indicate a code applicable to individuals, while social ethics is applicable to groups. Ethics is not limited to specific acts and defined moral codes. Also included is the whole of moral ideas and behaviors, a person's philosophy of life. A central aspect of ethics is "the good life", defined as the life worth living or life that is satisfying.

Applied ethics is a discipline of philosophy that attempts to apply ethical theory to real life situations. Usually, applied ethics is used to determine public policy. Business ethics is a form of applied ethics that examines ethical principles and moral or ethical problems that arise in a business environment. Under business ethics is the ethics of production, which deal with the duties of the company or industry to ensure that products and production processes do not cause harm. Very often situations arise in which there is conflict between one or more parties. For example an outcome might be good for industry, but may negatively impact the governing agency. Business has moral duties that extend well beyond serving the interest of its owners or stockholders, and these duties consist of more than simply obeying the law. A business has moral responsibilities to stakeholders, people who have an interest in the conduct of the business. Included in this group are employees, customers, vendors, the local community, and society as a whole.

As part of more comprehensive compliance and ethics programs, many companies have formulated internal policies pertaining to the ethical conduct of employers. The policies are generally meant to identify the company's expectations of workers and to offer guidance on handling some of the more common ethical problems that might arise in the course of doing business. To be successful, an ethics policy should be:

- Given the unequivocal support of top management, by word and example.
- Explained in writing and orally, with periodic reinforcement
- Doable…something employees can both understand and perform.
- Monitored by top management, with routine inspections for compliance and improvement.
- Backed up by clearly stated consequences in the case of disobedience.
- Remain neutral and nonsexist.

The foundation for ethical behavior goes well beyond corporate culture and the policies of any given company. Other factors are the individual's early moral training, the other institutions that affect an individual, the competitive business environment the company is in, and society as a whole.

ETHICS POLICY REVISIONS

North Carolina Department of Transportation

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ETHICS POLICY

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Preamble

The holding of a public office by appointment or employment is a public trust. Independence and impartiality of public officials and employees of the Department of Transportation are essential to maintain the confidence of our citizens.

The members of the Board of Transportation, officers and employees of the North Carolina Department of Transportation have a duty to the people of North Carolina to uphold the public trust, prevent the occurrence of conflicts of interest, and endeavor at all times to use their position for the public benefit.

To this end, members of the board, officers, and employees of the Department of Transportation shall ensure that an atmosphere of ethical behavior is promoted and maintained at all times.

Introduction

The major transportation functions of the North Carolina Department of Transportation (NCDOT) include highways, public transportation, motor vehicles, railways, bicycles, pedestrian facilities, aeronautics and ferries. The NCDOT is statutorily responsible for providing the necessary planning, construction, maintenance, and operation of an integrated statewide transportation system for the economical and safe transportation of people and goods as provided for by law, including the registration of transportation vehicles and driver's license. It is in the public interest to establish policies on ethical conduct which set forth a code of behavior to be followed by employees of the NCDOT that is consistent with federal and state laws, <u>as well as related Department policies.</u> These policies on ethical behavior are intended to guide the actions of all employees of NCDOT.

Employees of the NCDOT are expected to maintain and exercise the highest ethical standards of conduct in the performance of their duties and responsibilities, and as a condition of employment shall abide by this policy. Employees of the NCDOT are expected to conduct themselves in a manner that prevents all forms of impropriety, to include but not limited to, placement of self interest above public interest, partiality, prejudice, favoritism and undue influence.

This policy applies to all employees of the NCDOT and shall be brought to the attention of each employee during orientation and during annual training by Human Resources. Failure to comply with this policy will be grounds for disciplinary action up to and including dismissal.

Definitions

1. Conflict of interest

A conflict of interest arises when an employee's private interest, usually of a personal, financial or economic nature, conflicts or creates the appearance of a conflict with the employee's public duties and responsibilities.

2. Gift

A gift is anything of value given without compensation.

3. Favor

A favor is any opportunity, service, accommodation, use of facility, or other benefit made available for less than fair market or normal value given in exchange for being influenced in the discharge of one's duties and responsibilities.

4. Employee

Employee for the purposes of this policy shall mean both State officer and employee holding an office or employment with the North Carolina Department of Transportation.

5. Family

Family for the purposes of this policy includes spouse, you and your spouse's children, parents, in-laws, step-parents, step-child, step-sibling, grandchildren, brother, sister, uncle, aunt, first cousin, also any dependent person living in the same household.

I. Conflict of Interest

No employee shall have any interest, financial or otherwise, direct or indirect, or engage in any business, transaction or activity that is in conflict or could appear to be in conflict with the proper discharge of his or her duties. An appearance of a conflict of interest exists when a reasonable person would conclude from the circumstances that the employee's ability to protect the public interest, or perform public duties, is compromised by personal interest. Examples of conflict of interest are as follows:

A. Misuse of Official Position

No employee shall use or attempt to use his or her position with the NCDOT to secure unwarranted privileges or advantages for himself, herself or others.

B. Contracts and Purchasing Order Agreements

No employee authorized to draft, negotiate, administer, accept or approve any contract, subcontract or purchase order agreement on behalf of the State, or any member of his/her family, shall have, directly or indirectly, any financial interest in such contract, subcontract or purchase order agreement.

In an effort to avoid the appearance of impropriety while conducting the public's business, employees will be restricted from accepting any employment or engaging in any relationship following their employment with NCDOT with any business entity in connection with any contract, subcontract or purchase order agreement that they participated in any of the following activities:

1. Drafting the contract, subcontract or purchasing order agreement;
2. Defining the scope of the contract, subcontract or purchasing order agreement;
3. Selection of the business entity for services;
4. Negotiation of the cost of the contract, subcontract or purchasing order agreement, including calculation of man-hours, fees or extent of services;
5. Administration of the contract or purchase order agreement.

This section is not intended to prohibit employment with a business entity if the employment is on work other than the specific contract, subcontract or purchase order agreement with which they were involved. An exception to this section of the policy may be granted when recommended by the Secretary of Transportation and approved by the Board of Transportation.

C. Real/Personal Property

No employee or member of his/her family shall use an employee's position to profit from, directly or indirectly, an interest in real or personal property.

D. Business Opportunities

No employee or member of his/her immediate family shall accept any business or professional opportunity when such person knows, or reasonably should know, that the opportunity is being afforded to them with the intent to influence the performance of the employee's official duties.

E. Outside Employment and Activities

In accordance with NCDOT Secondary Employment policy, the employment responsibilities to the State are primary for any employee working full-time and and other employment in which that person chooses to engage is secondary. An employee shall have the approval from the division, branch or unit manager before engaging in any secondary employment.

No employee shall accept employment or render services for any private or public interest when that employment or service is in conflict with the discharge of his or her official duties or when that employment may tend to impair his or her objectivity or independence of judgement in the performance of such duties or induce them to disclose confidential or any information gained through their State duties.

F. Use of Information

No employee shall, directly or indirectly, use, disclose, or allow the use of official information which was obtained through or in connection with his or her official duties and which has not been made available to the general public for the purpose of furthering the private interest or personal profit of any business entity or person, including the employee.

II. Gifts and Favors

No employee should knowingly, directly or indirectly, ask, accept, demand, exact, solicit, seek, assign, receive, or agree to receive anything of value for the employee or for another person, in return for being influenced in the discharge of the employee’s duties and responsibilities.

No employee shall solicit for a charitable purpose a gift from a subordinate employee, except as provided in NC Gen. Stat. Section 138A-32 (b).

No employee shall solicit or accept, directly or indirectly, on behalf of himself or herself or family member, any gift or favor from a contractor, subcontractor, vendor, supplier, lobbyist or any other individual or other business entity that:

1. Has or is seeking to obtain contractual or other business or financial relations with the Department;
2. Conducts operations or activities that are regulated by the Department;
3. Have interests that may be substantially affected by the performance or non-performance of the employee’s official duties.

Exceptions to this section, gifts and favors, are noted in NC Gen. Stat. Section 138A-32 (e).

Any such gift or favor received from a contractor, subcontractor, supplier, lobbyist or any other individual or other business entity must be reported and remitted immediately through the appropriate chain of command to the Secretary of Transportation.

III. Consultation

Employees are urged to consult with the Division of Human Resources, Classification, Compensation & Policy Unit staff when an ethical question arises under this policy.

IV. Distribution and Training of Ethics Policy

A copy of this policy will be presented to all new employees at the time of employment and posted in a conspicuous place throughout the Department and made available on the NCDOT web site.

Training shall be provided by Human Resources every other year.

V. Enforcement and Compliance

This policy will be enforced by the Secretary of Transportation. Failure to comply with the above policy will be grounds for disciplinary action up to and including dismissal from employment with the NCDOT. Conflicts of interest or unethical behavior that defrauds the Department , vendor, contractor, subcontractor, or supplier may also be violations of criminal law an may result in criminal prosecution.

VI. Disclosures

Any employee who identifies a conflict of interest shall disclose the same promptly in writing through appropriate management channels to the Secretary of Transportation.

FALSIFICATION

North Carolina State Law G.S. Chapter 136, Roads and Highways

13.2 Falsifying highway inspection reports.

(a) Any person who knowingly falsifies any inspection report or test report required by the Department of transportation in connection with the construction of highways shall be guilty of a Class H Felony.

(b) Any person who directs a subordinate under his direct or indirect supervision to falsify an inspection report or test report required by the Department of Transportation in connection with the construction of highways shall be guilty of a Class H Felony.

Punishment for a Class H Felony can result in up to 10 years in jail, up to $10,000.00 in fines, or both.

Federal Law Title 18-Crimes and Criminal Procedure

Part I- Crimes

Chapter 47- Fraud and False Statements

Section 1020. Highway Projects

Whoever, being an officer, agent, or employee of the United States, or of any State or Territory, or whoever, whether a person, association, firm, or corporation, knowingly makes any false statement, false representation, or false report as to the character, quality, quantity, or cost of the material used or to be used, or the quantity or quality of the work performed or to be performed, or the costs thereof in connection with the submission of plans, maps, specifications, contracts, or costs of construction of any highway or related project submitted for approval to the Secretary of Transportation; or Whoever knowingly makes any false statement, false representation, false report, or false claim with respect to the character, quality, quantity, or cost of any work performed or to be performed, or materials furnished or to be furnished, in connection with the construction of any highway or related project approved by the Secretary of Transportation; or

Whoever knowingly makes any false statement or false representation as to a material fact in any statement, certificate, or report submitted pursuant to the provisions of the Federal-Aid Road Act approved July 11, 1916 (39 Stat. 355), as amended and supplemented,

Shall be fined under this title $10,000.00 or imprisoned not more than five years, or both.

Falsification of Records is defined as the changing or misrepresentation of Data or Tests. Falsification also includes the destruction or alteration of records.

SECTION IV

NCDOT FORMS

NCDOT M&T Form 903

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Batch ticket for Central and Transit-Mix Concrete. To accompany each load of concrete delivered. Not applicable on concrete pavement if batch plant set for project.

1. Ticket No. ______________________ Date ______________
2. Project No. ______________________ Mortar Content ______________
3. Plant Name ______________________ State No. ______________
4. Truck No. __________ Truck Load ______ C.Y. Accum. Yard ______ C.Y.
5. Class Concrete ______________________ Free Moisture F.A. ______________
6. Mix Design No. ______________________ Free Moisture C.A. ______________
7. Maximum water permitted per cu.yd. ______________ gals.
8. Total mixing water per cu.yd. ______________ gals.
9. Additional water which may be added per cubic yard and not exceed maximum wlc ratio ______ gals.
10. Air agent ounces per yard ______________________
11. Retarder ounces per 100 # cement ______________________
12. Other admixtures and amount used ______________________
13. Time batching completed ______________ If ice used ______ lbs/load
    (A minimum of 70 revolutions at mixing speed is required at the batching plant and/or at the work site.)
14. Number of revolutions at mixing speed at plant ______________________
    (See nameplate or mixer for proper mixing speed.)

____
Certified Technician Cert. No.

TO BE FILLED OUT BY FIELD INSPECTOR

Station ______________________________
Structure Member ______________________________
Additional Water Added ______________ gals (Not to Exceed Line 9)
(If additional water is added, minimum of 25 revolutions of the mixer drum at mixing speed shall be made)
No. revolutions at mixing speed at job site: ______________
Time at completion of discharge: ______________
Slump __________ Temperature: Air ________ °F. Concrete ________ °F.
Pressure meter air test ______________ % Air
Air indicator stem reading ______ X ______ = ______ + ______ = ______ % Air
Factor Curve Corr.
Sample No. of Cylinders made from this load: ______________

____
Project Inspector

CHACE INDICATOR CORRECTION TABLES

Use only 70% Alcohol

Table 1
Mortar Correction Factors

Chase Indicator

Mortar Content ft^3/yd	Scratched on glass Indicator 1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
27	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40
20	1.19	1.26	1.33	1.41	1.48	1.56	1.63	1.71	1.78
19	1.13	1.20	1.27	1.34	1.41	1.48	1.55	1.62	1.69
18	1.07	1.14	1.20	1.27	1.33	1.40	1.47	1.54	1.60
17	1.01	1.07	1.13	1.20	1.26	1.33	1.39	1.45	1.51
16	0.95	1.01	1.07	1.13	1.19	1.25	1.30	1.36	1.42
15	0.89	0.95	1.00	1.06	1.11	1.17	1.22	1.28	1.33
14	0.83	0.88	0.93	0.99	1.04	1.09	1.14	1.19	1.24
13	0.77	0.82	0.87	0.92	0.96	1.10	1.06	1.11	1.16
12	0.71	0.76	0.80	0.85	0.89	0.94	0.98	1.03	1.07
11	0.65	0.69	0.73	0.77	0.81	0.86	0.90	0.94	0.98
10	0.59	0.63	0.67	0.71	0.74	0.78	0.81	0.85	0.89

Table 2
Curve Correction

Mortar Corrected Air Content (%)	Curve Correction (%)	Mortar Corrected Air Content (%)	Curve Correction (%)
1.0	-0.1	7.0	0.8
2.0	0.0	7.5	0.9
3.0	0.2	8.0	1.0
3.5	0.3	8.5	1.1
4.0	0.3	9.0	1.2
4.5	0.4	9.5	1.3
5.0	0.5	10.0	1.3
5.5	0.6	11.0	1.5
6.0	0.7	12.0	1.7
6.5	0.8	13.0	1.8

STEP BY STEP METHOD OF FILLING OUT M&T FORM 903

1. Line One: The Ticket Number runs consecutively each day for each class of concrete. The Date is the date the concrete is being batched.

2. Line Two: The Project Number is the NCDOT project the concrete is being sent to. The Mortar Content comes from the approved mix design (Form 312).

3. Line Three: The Plant Name is the firm that is supplying the concrete. The State Number is assigned to each plant that has been certified.

4. Line Four: The Truck Number comes off the Ready Mix truck and should appear on the up-dated "Approved Truck List" for that plant. The TruckLoad is the cubic yards of concrete being carried to the job. The Accumulative Yardage is the yards sent to that project that day of that class of concrete.

5. Line Five: The Class of Concrete is the DOT classification of concrete, which comes from the approved mix design. The Free Moisture Fine Aggregate is expressed as a percentage and should be run at least once a day.

6. Line Six: The Mix Design Number comes from the approved mix design Form 312. The Free Moisture Coarse Aggregate is expressed as a percentage and should be run at least once a day.

7. Line Seven: The Maximum Water Permitted Per Cubic Yard is recorded in gallons and comes from the approved mix design.

8. Line Eight Total Mixing Water Per Cubic Yard is recorded in gallons and includes all metered water plus all water in the form of free moisture located in the fine and coarse aggregate.

9. Line Nine: Additional Water is the difference between the maximum water permitted per cubic yard and the total mixing water used per cubic yard (Line 7 - Line 8). THIS MAY NEVER EXCEED THE MAXIMUM WATER CEMENT RATIO!

10. Line Ten: Air Agent Ounces Per Yard is the amount used per cubic yard to entrain 6.0% air 1.5% as determined by the Producer.

11. Line Eleven: Retarder Ounces Per 100* Cement is determined by the brand being used and comes off the updated "Approved Admixture List" and is based on the air temperature or the concrete temperature — whichever is highest.

12. Line Twelve: Other Admixtures And Amount Used is any additional admixtures which may have been used, (i.e. superplasticizers.)

13. Line Thirteen: Time Batching Completed is the time when all materials are batched into truck. If Ice Used, the total pounds used in the truckload **I** should be recorded and subtracted from the metered water.

14. Line Fourteen: Number Of Revolutions At Mixing Speed At Plant is the, actual number of evolutions at mixing speed as recommended by the manufactures rating plate on the truck should be recorded before the truck leaves the plant.

15. Line Fifteen: Certified Technician and Certification Number is the current certified Concrete Technician or Batcher performing the operations. He/She should sign their name and certificate number to the ticket. Only those currently certified may sign the batch ticket.

TO BE FILLED OUT BY FIELD INSPECTOR
BOTTOM OF FORM

1. Station: the station number where the concrete is being placed.

2. Structure Member: is the type of use the concrete is being used in (Bridge Deck, Footing, Curb and Gutter, etc.).

3. Additional Water Added: is any water added to the load after the mixing process is complete. This amount should not exceed the amount shown on Line 9 of the batch ticket.

4. Number Revolutions At Mixing Speed At Job Site: if any additional mixing is needed on the job site, it is recorded. There is no maximum number of revolutions.

5. Time At Completion Of Discharge: the time when all the concrete is off the truck is recorded and must not exceed elapsed time for placing concrete as shown in the Specifications.

6. Slum Temperature Air, and Temperature Concrete: he slump should be recorded to the nearest 1/4". The air and concrete temperatures should be recorded to the nearest one-degree Fahrenheit.

7. Pressure Meter Air Test: is recorded to the nearest 1/10% and should range between 4.5% and 7.5%.

8. Air Indicator: a calibrated Chace Air indicator should be used. The stem reading is taken directly off the Chace glass tube after the procedure is completed and recorded. The stem reading is then multiplied by the value determined from Table 1, from the back of the batch ticket (using the Mortar Content and Chace Indicator Calibration Number). The mortar-corrected air content is now added to the Curve Correction value, determined from Table 2 (located on the back of the batch ticket). This value will give you the corrected Chace Air. The Chace Air should range from 4.5% to 7.5%.

9. Cylinders: if cylinders are made from the load of concrete, the sample number of the cylinders is recorded and the inspector performing the field tests on the concrete should sign the ticket.

This ticket serves two important functions:

1. Communication: it serves as a means of communication between the Batcher at the plant and the inspector in the field.
2. Documentation: it serves as a permanent record for the project in case it is needed for reference anytime in the future.

NCDOT Form 312U 3-96

North Carolina Department of Transportation, Division of Highways, Materials and Tests Unit Statement of Concrete Mix Design and Source of Materials

Project 8.2446902	Concrete Producer HOME CONCRETE INC
County TRANSYLVANIA	Plant Location & DOT No. CHERRYFIELD, NC -69
Resident Engr. DRACK COUNT	Contractor BLOOD CONSTRUCTION CO
Class of Concrete CLASS AA	Date AUGUST 27, 2003
Mix Design No. 0692V03333FFE	Contractor's Signature
Note Mix Design Units (US or Metric) ENG	

Mix Design Proportions Based on SSD Mass of Aggregates

Material	Producer	Source	Qty. per Cu. Yd.
Cement, Type	GIANT	HARLEYVILLE, SC	650 lbs.
Pozzolan			
Fine Agg., + M	FRANK-N-STIEN	PUMPKINGTOWN, SC	1154 lbs.
Coarse Agg., + M	DARKTOWN STONE	BREVARD, NC	1800 lbs.
Other Agg., + M			
Total Water		CITY	32.0 gals.
Air. Entr. Agent	W.R.GRACE & CO.	DARAVAIR AT60	3.0 oz.
Retarder	W.R.GRACE & CO.	DARATARD 17	22.0 (OZ/100#) oz.
Water Reducer			
Superplasticizer			
Other			
Other			

Mix Properties and Specifications

Slump	3.50 in.	Mortar Content	16.20 cu. ft.
Max. Water	33.2 gals.	Air Content	6.0 %

Aggregate and Pozzolan Data

Material	Specific Gravity	% Absorption	Unit Mass	Fineness Modulus
Material Fine Agg. Type (2S or 2MS)	2.64	0.4	NA	2.70
Coarse Agg., Size (No. 57, 67, or 78M)	2.67	0.6	97.5	NA
Other Agg., Type or Size				
Pozzolan		NA	NA	NA

Cast-in-place concrete shall conform to Section 1000, precast concrete to Section 1077, and prestressed concrete to Section 1078 of the 1995 Standard Specifications for Roads and Structures plus all applicable Special Provisions.

Accepted By ________________________ (Physical Testing Engineer) Date __________

M&T Form 903

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Batch ticket for Central and Transit-Mix Concrete. To accompany each load of concrete delivered. Not applicable on concrete pavement if batch plant set for project.

1. Ticket No. 1 Date Oct. 31, 2003
2. Project No. 8.2446902 Mortar Content 16.20
3. Plant Name Home Concrete Inc State No. 69
4. Truck No. 15 Truck Load 8.0 C.Y. Accum. Yard 8.0 C.Y.
5. Class Concrete Class AA Free Moisture F.A. 1.6 %
6. Mix Design No. 0692VO3333FFE Free Moisture C.A. 2.1 %
7. Maximum water permitted per cu.yd. 33.2 gals.
8. Total mixing water per cu.yd. 32.0 gals.
9. Additional water which may be added per cubic yard and not exceed maximum wlc ratio 1.2 gals.
10. Air agent ounces per yard 3.0
11. Retarder ounces per 100 # cement 22.0
12. Other admixtures and amount used None
13. Time batching completed 3:25 pm If ice used None lbs/load
    (A minimum of 70 revolutions at mixing speed is required at the batching plant and/or at the work site.)
14. Number of revolutions at mixing speed at plant 75
    (See nameplate or mixer for proper mixing speed.)

Jay Hardwork PCB 0000

Certified Technician Cert. No.

TO BE FILLED OUT BY FIELD INSPECTOR

Station 12+50, 35 feet right of the centerline
Structure Member Bent #2 – Column A Drill Shaft
Additional Water Added 4.0 gals (Not to Exceed Line 9)
(If additional water is added, minimum of 25 revolutions of the mixer drum at mixing speed shall be made)
No. revolutions at mixing speed at job site: 35
Time at completion of discharge: 3:45 pm
Slump 3.25" Temperature: Air 75 °F. Concrete 77 °F.
Pressure meter air test 6.40 % Air
Air indicator stem reading 4.25 X 1.30 (Factor) = 5.5 + 0.6 (Curve Corr.) = 6.1 % Air
Sample No. of Cylinders made from this load: P-2468

Justin Time PCT 000A

Project Inspector

M & T Form 250
Rev. 3/10

North Carolina Department of Transportation
DAILY PLANT REPORT ON READY MIXED CONCRETE OPERATIONS

Contract No. / Work Order No. COEXAM Date ______

Cement Producer Roanoke Cement Producer Location Roanoke

Pozzolan Producer Proash Fine Agg Source MM Belgrade Q Maysville

Ready Mix Facility & No. Ready Concrete Company Coarse Agg Source MM Clarks Q New Bern

Class of Concrete	Mix Design No.	Number of Loads	Total Yards Batched	Total Yards Rejected (To be completed by field inspector)
AAvib	**Exammix 1**	**8**	**45**	

MOISTURE IN AGGREGATES

Fine Aggregate:

Trial 1 Time: 8:00am

Wet Wt. 525.4 Minus Dry Wt. 500.2 = .050 X 100 = 5.0 % Total Moisture

Dry Wt. 500.2

Total Moisture 5.0 Minus Absorbed Moisture 0.5 = 4.5 *(2)* % Free Moisture

Trial 2 Time: 1:00pm

Wet Wt. 550.4 Minus Dry Wt. 520.2 = .039 X 100 = 3.9 % Total Moisture

Dry Wt. 520.2

Total Moisture 3.9 Minus Absorbed Moisture 0.5 = 3.4 *(2)* % Free Moisture

Coarse Aggregate:

Trial 1 Time: 8:00am

Wet Wt. 1503.9 Minus Dry Wt. 1485.1 = .013 X 100 = 1.3 % Total Moisture

Dry Wt. 1485.1

Total Moisture 1.3 Minus Absorbed Moisture 0.4 = 0.9 *(2)* % Free Moisture

Trial 2 Time: 1:00pm

Wet Wt. 1563.9 Minus Dry Wt. 1545.1 = .012 X 100 = 1.2 % Total Moisture

Dry Wt. 1545.1

Total Moisture 1.2 Minus Absorbed Moisture 0.4 = 0.8 *(2)* % Free Moisture

Certified Batcher Signature: ______ Certification No. ______

Certified Field Inspector Signature: ______ Certification No. ______

M&T Form 250 is to be completed by certified batcher, pink copy of form shall be sent with first load, and the completed white (original) copy shall be sent with final load. If form is not completed and received on site, concrete is subject to rejection.

Sample Card

* Required Field

☐ Metric
☐ English

t May Be Required Based on Material

HiCAMS #:

*** Material:** ________________

t Sample Owner: ________ t Contract #: ________

* Testing Category: ________ Field ID: ________

Check Sample? **Y N** (Circle One) Proj/Po/Wo#: ________

t Related Sample ID: ________ Line Item #: ________

t Corr. Sample ID: ________ RE: ________

\# of Pieces: ________ *** Rep. Qty:** ________

*** To Be Used In:** ________________

Comment:

*** Sample Date:** ________ *** Sample By:** ________

*** Sample From:** ________ Truck/ Container #: ________

Structure Number: ________ Route Desc: ________

Route Type: I US NC SR (Circle One) Alignment: ________

Route Number: ________ * Location: ________ Offset Dist: ________

Map Number: ________ * Sta. From: + Sta. To: + +

County: ________ Coastal Plain: Y N (circle One)

☐ Other

t Producer/Supplier: ________ t Plant ID: ________

t Brand Name: ________ Shelf Life Date: ________

t Date produced: ________

t Concrete Mix: ________ t Asphalt Mix/ JMF ID: ________

t Alternate Ids Type:	**Prefix:**	**Range:**	**Description of Items:**
☐			

Please use reverse side for test data, comments, and additional information. Check here if more on reverse

Sample Card for Home Concrete Inc Ready Mix

* Required Field

☐ Metric
☐ English

t May Be Required Based on Material

HiCAMS #:

* Material: Class AA Drill Shaft

t Sample Owner: Project

t Contract #:

* Testing Category: Acceptance

Field ID:

Check Sample? Y N (Circle One)

Proj/Po/Wo#: 8.2446902

t Related Sample ID:

Line Item #:

t Corr. Sample ID:

RE:

# of Pieces:

* Rep. Qty: 32 cu yds

* To Be Used In: Drill Shaft

Comment:

---

* Sample Date: October 31, 2003

* Sample By: Holly Hicky

---

* Sample From: Concrete Truck

Truck/ Container #: 15

Structure Number: Bent # 2

Route Desc:

Route Type: I US NC SR (Circle One)

Alignment:

Route Number:

* Location:

Offset Dist:

Map Number:

* Sta. From: 12 + 50

Sta. To: + +

County:

Coastal Plain: Y N (circle One)

☐ Other

t Producer/Supplier: Billy-Bob's Ready Mix

t Plant ID: 69

t Brand Name:

Shelf Life Date:

t Date produced:

t Concrete Mix: 0692VO3333FFE

t Asphalt Mix/ JMF ID:

---

t Alternate Ids Type: Prefix: Range: Description of Items:

☐

Please use reverse side for test data, comments, and additional information. Check here if more on reverse

SECTION V

FIELD TEST PROCEDURES AND STANDARDS

THE TESTING OF PORTLAND CEMENT CONCRETE

The NCDOT goal is to insure that a durable, quality and economic concrete material is produced, delivered and installed in all concrete structures owned by the State of North Carolina. In doing so, the NCDOT maintains a quality assurance process that includes field testing of all concrete used in NCDOT projects to verify compliance with NCDOT specifications and requirements. Field tests are run by an NCDOT approved inspector. As of July 1st 1992, the concrete inspector must be a certified concrete technician in accordance with both NCDOT and ACI requirements.

The test type, ranges of acceptability, and associated policies and directives are included in sections I, II and III of this book as specified by the NCDOT in its most current specifications. As noted in section III (c), the NCDOT requires that each test be conducted with a minimum frequency criteria. Section IV presents information concerning procedures for mixture submittal, and for recording and reporting field tests in compliance with NCDOT specifications. Section V presents information concerning acceptable test procedures, which must be performed in accordance to the noted ASTM and AASHTO standards.

The following table presents a summary of the field tests, and their corresponding standard test method, required by the NCDOT

TESTS	AASHTO	ASTM
Temperature of Freshly Mixed Concrete		C-1064
Sampling Freshly Mixed Concrete	T-141	C-172
Slump of Hydraulic Cement Concrete	T-119	C-143
Density (Unit Weight) of Concrete	T-121	C-138
Air Content by Pressure Method	T-152	C-231
Air Content by Volumetric Method	T-196	C-173
Making and Curing Test Specimens	T-23	C-31
Air Content by Chace Indicator	T-199	

In general, field tests required by the NCDOT focus on the strength, consistency, air content, and temperature characteristics of the concrete mixture.

Strength tests are of two types: compressive and flexural. Compressive strength tests are normally run on structural and incidental concrete elements as classified by the NCDOT. Flexural strength tests are normally run on pavement concrete mixtures. The consistency of the fresh concrete is determined by measuring its slump. Abnormal variations in slump can provide an indication of changes affecting the concrete mixture that could in turn affect the in-place quality and performance of the concrete. Tests for air content are conducted utilizing the Chace indicator (in all truck loads), the pressure meter (in all normal-density concrete), and the volumetric meter (in all concrete made with lightweight and marine limestone aggregates as noted in section III (a)).

Except for strength tests (which are normally tested several days after the mixture is in place), all other field tests provide immediate feedback concerning compliance of a concrete mixture with NCDOT requirements for consistency, temperature, and air content. Concrete can be rejected in accordance with applicable NCDOT policies for the test and the type of concrete or structure under control. Section II includes information relevant to actions and procedures for instances when a test falls outside acceptable limits.

TEMPERATURE FOR FRESHLY MIXED CONCRETE (ASTM C-1064)

1. Run temperature test on first load and when cylinders or beams are made.
2. Use a calibrated thermometer.
3. Insert probe into sample a minimum of 3 inches for a minimum time of two minutes. The probe shall be surrounded by at least 3 inches of concrete in all directions.
4. Record temperature to the nearest 1º F.
5. Concrete temperature for incidental and structural concrete, 50º - 95º for all except bridge decks and drilled piers. Bridge deck and drill pier concrete placement temperature is 50º - 90º F. Cold weather specifications applies when one of the components is heated. When a component is heated, the temperature range is 55º - 80ºF.
6. Temperature test must be completed within 5 minutes after obtaining sample.

SAMPLING FRESHLY MIXED CONCRETE (ASTM C-172)

1. Upon arrival of the concrete on the project the inspector checks the batch ticket to verify the project number and class of concrete match up with the mix design. The inspector notes the time batching is completed to ensure placement time is not exceeded. Also the inspector determines based on the batch ticket how much water is allowable to be added.
2. The contractor verifies that the mix will provide the workability required. If additional water is needed the contractor is allowed to add up to the limit the inspector communicates.
3. Once the contractor adds all water to be used the inspector samples the concrete. The acceptance tests for slump and air must begin within 5 minutes of the time the sample is obtained. Temperature test should begin immediately.
4. Test specimens are to be made within 15 minutes after obtaining the sample.
5. Concrete should be sampled from the discharge end of placement. If concrete is pumped, the sample shall be obtained from the end of the pump for acceptance testing.
6. Obtain the sample by passing the receptacle through the entire discharge stream or divert the stream completely into a sampling container.

SLUMP TEST ASTM C-143

The equipment needed to run the slump test is shown above. The slump cone, a tamping rod, a scoop, a ruler, and a non-absorbent surface that is stable and level.

Thoroughly remix the sample of concrete prior to testing.

Remember: Air, Temperature and Slump tests must be **started** within 5 minutes after the composite sample is prepared. The temperature test must be **finished** within these first 5 minutes.

Moisten the slump cone and the testing surface prior to filling of the cone.

Stand on the foot pieces to hold the cone firmly in place. Do not step off at any time until cone is to be lifted.

Fill the cone mold 1/3 full by volume with concrete (2 5/8 in. depth), distributing concrete evenly.

Rod the first layer 25 times. Slightly incline rod, distributing rodding strokes over entire cross section of the cone, penetrating the entire depth of the layer. DO NOT tap the side of the cone.

The second layer is to be filled up to 2/3 by volume (6 1/8 in. depth), distributing concrete evenly.

Rod the second layer 25 times, the rod should penetrate the first layer by 1 in. DO NOT Tap the sides of the cone.

Fill the third and final layer until concrete overflows.

Rod 25 times with the rod penetrating 1 in. into the second layer. Distribute the strokes evenly. DO NOT tap the sides of the cone. Keep the 3rd layer full at all times.

Strike off all excess concrete. Make sure you do not step off the cone at this time.

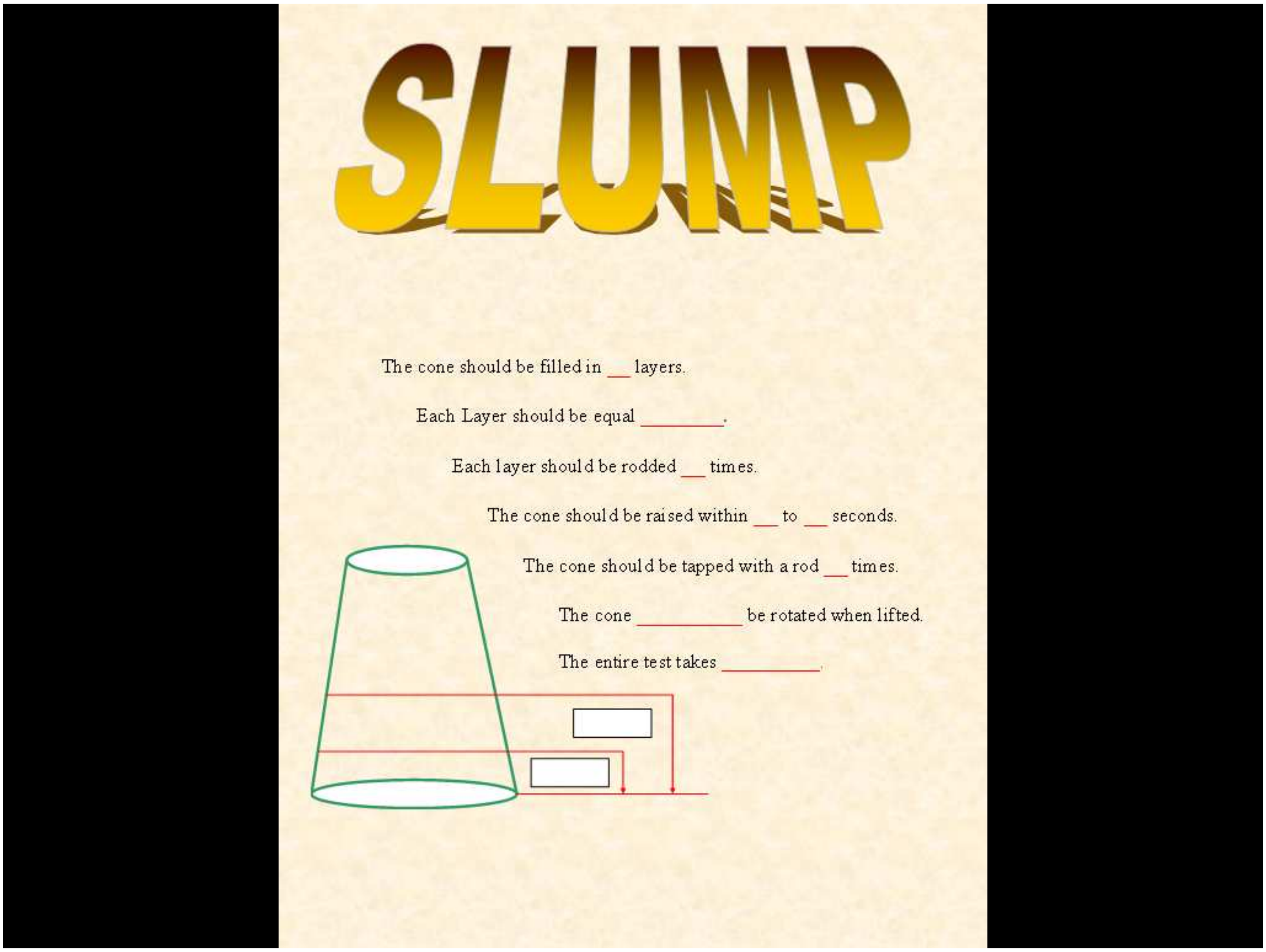
Clean any excess concrete from the top and around the cone, making sure the cone is completely full.

Immediately after completion of cleaning, place hands on the handles and supply downward pressure, then remove feet while holding the cone firmly.

Lift the cone in a steady upward motion with no twisting. This operation must be completed between 3 and 7 seconds.

Invert the cone and place the rod across the top. Measure the distance from the rod to the original displaced center to the nearest 0.25 in. Record the slump. The time limit for this operation is 2.5 minutes.

Clean your equipment. Do not reuse the tested concrete. Do not perform a slump test until all water has been added to the load (this includes adding water at the site). If the slump is out of specification, immediately clean up equipment and perform another test.



1. Perform test on first load, and random load per 30 cubic yards, and when cylinders are made.
2. Add all water before test is performed.
3. Begin test within 5 minutes after obtaining the sample.
4. Test to be completed in 2.5 minutes.
5. Record slump to the nearest ¼ inch.
6. Slump measures consistency.

DENSITY (UNIT WEIGHT) TEST ASTM C-138

The equipment needed to run the unit weight test is shown above. A scale, a unit weight bucket, a tamping rod, a scoop, a rubber mallet, a strike-off plate, a calculator, pencil, and paper, and a level surface.

Thoroughly remix the sample of concrete prior to testing.

Record a weight of the bucket empty.

Moister and/or clean the unit weight bucket, and empty excess water.

Fill the measuring bucket with concrete to about 1/3 of its volume, distributing concrete evenly.

Rod the first layer without hitting bottom of the bucket. Distributing rodding strokes over entire cross section of the bucket, penetrating the entire depth of the layer.

Consolidate the concrete by tapping the sides of the bucket 10 – 15 times.

The second layer is to be filled to approximately 2/3 of the measure volume, distributing concrete evenly.

Rod the second layer, penetrating the first layer by 1 in.

Consolidate second layer by tapping side of bucket 10 – 15 times.

Fill the third and final layer. Rod the third layer with the rod penetrating 1 in. into the second layer. Distribute the strokes evenly.

Tap 10 – 15 times to consolidate.

Place strike-off plate covering 2/3 of surface of the bucket. With a side to side sawing motion, bring plate toward you creating a smooth finish.

Place the strike-off plate again on the bucket, covering about 2/3 of the top surface. Continuing with the side to side sawing motion, force the plate in the forward direction creating a smooth finish. Repeat strike-off plate operation if necessary until a smooth surface is achieved.

Clean off all excess concrete from the sides, handles, and bottom of the bucket.

The amount of concrete should be LEVEL with the top of the bucket. Weight the bucket full of concrete and calculate the unit weight.

NOTE:

If bucket volume is 0.5 ft^3 or smaller, each layer is rodded 25 times. If bucket volume is greater than 1.0 ft^3, then each layer is rodded 50 times.

Formula for calculating the UNIT WEIGHT of CONCRETE:

$$\textbf{UNIT WEIGHT} = \frac{\textbf{WEIGHT OF CONCRETE AND BUCKET (in pounds)} - \textbf{WEIGHT OF BUCKET (in pounds)}}{\textbf{VOLUME OF BUCKET (in cubic feet)}}$$

UNIT WEIGHT (units) = lbs/cf (pounds per cubic foot)

Formulas for calculating the YIELD of a CONCRETE BATCH:

$$\textbf{YIELD} = \frac{\textbf{TOTAL WEIGHT OF MATERIALS IN THE BATCH (in pounds)}}{\textbf{UNIT WEIGHT OF CONCRETE IN THE FIELD (pounds per cubic foot)}}$$

YIELD (units) = cf (cubic feet)

2) To calculate yield in cubic yards, use the following formula, or divide cubic ft by 27.

$$\textbf{YIELD} = \frac{\textbf{TOTAL WEIGHT OF MATERIAL IN THE BATCH (in pounds)}}{\textbf{UNIT WEIGHT OF CONCRETE IN THE FIELD (pounds per cubic feet)} \times \underline{\textbf{27}}}$$

YIELD (units) = cy (cubic yards)

Formula for calculating the GRAVIMETRIC % AIR of CONCRETE:

$$\textbf{\% AIR} = \frac{(T - W)}{T} \times 100$$

T = Theoretical weight of concrete computed on air-free basis.
W = Unit weight of concrete (field unit weight).

AIR (units) = % (percent)

Examples

Density

Wt of empty bucket	23.20 pounds
Wt of concrete and bucket	94.80 pounds
Volume of bucket	0.51 cubic ft

$$\frac{94.80 - 23.20 \text{ pounds}}{0.51 \text{ cubic ft}} = 140.39 \text{ pounds per cubic ft} \quad \text{(pcf)}$$

Yield

Given the following weights, determine the yield.

Cement	564 pounds
Stone	1948 pounds
Sand	1100 pounds
Water	34.5 gallons

Field Density 144.20 pcf

Add all materials in pounds.

$$564 + 1948 + 1100 + (34.5 \times 8.33) = 3899 \text{ pounds}$$

$$\text{Yield} = \frac{3899 \text{ pounds}}{144.20 \text{ pcf}} = 27.03 \text{ cubic ft}$$

To compute yield in cubic yds, divide 27.03 Cu ft / 27 to get 1.0 cu yd

Air

Theoretical Density = 159.65 pcf

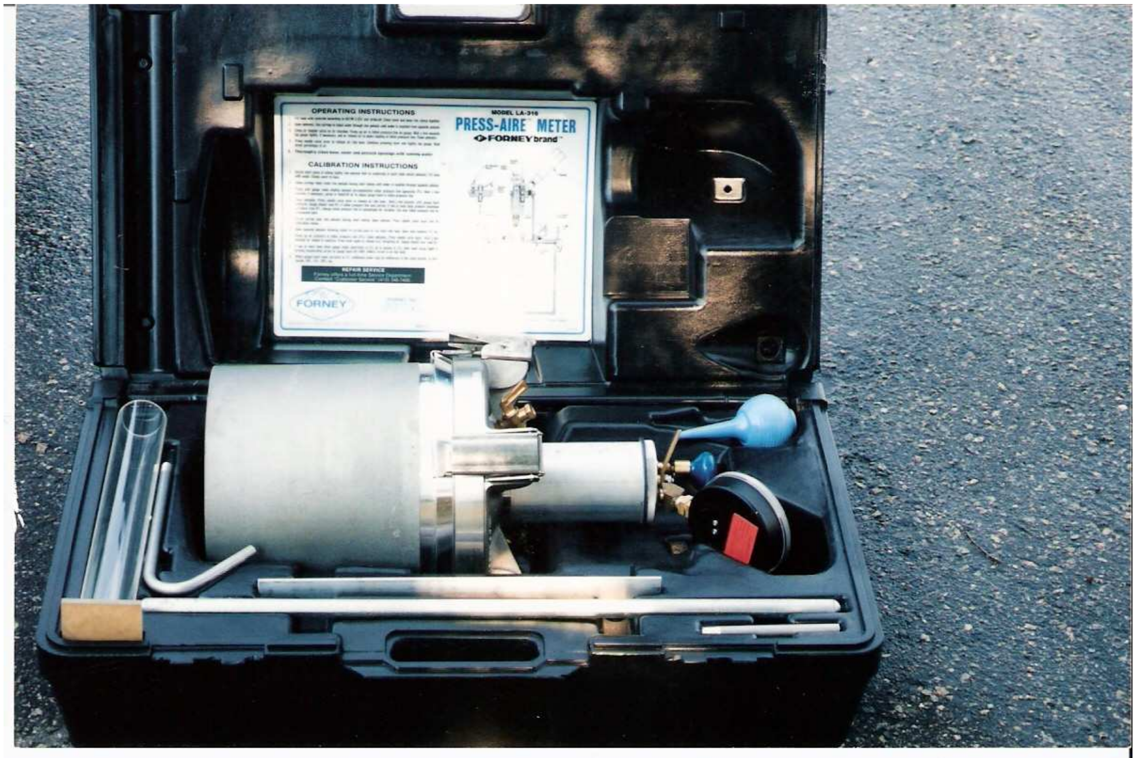
Density (D) = 149.20 pcf

What is the % air content ?

$$\% \text{ Air} = \frac{159.65 - 149.20}{159.65} \times 100$$

$$\% \text{ Air} = 6.5\ \%$$

TYPE B PRESSURE AIR METER ASTM C-231



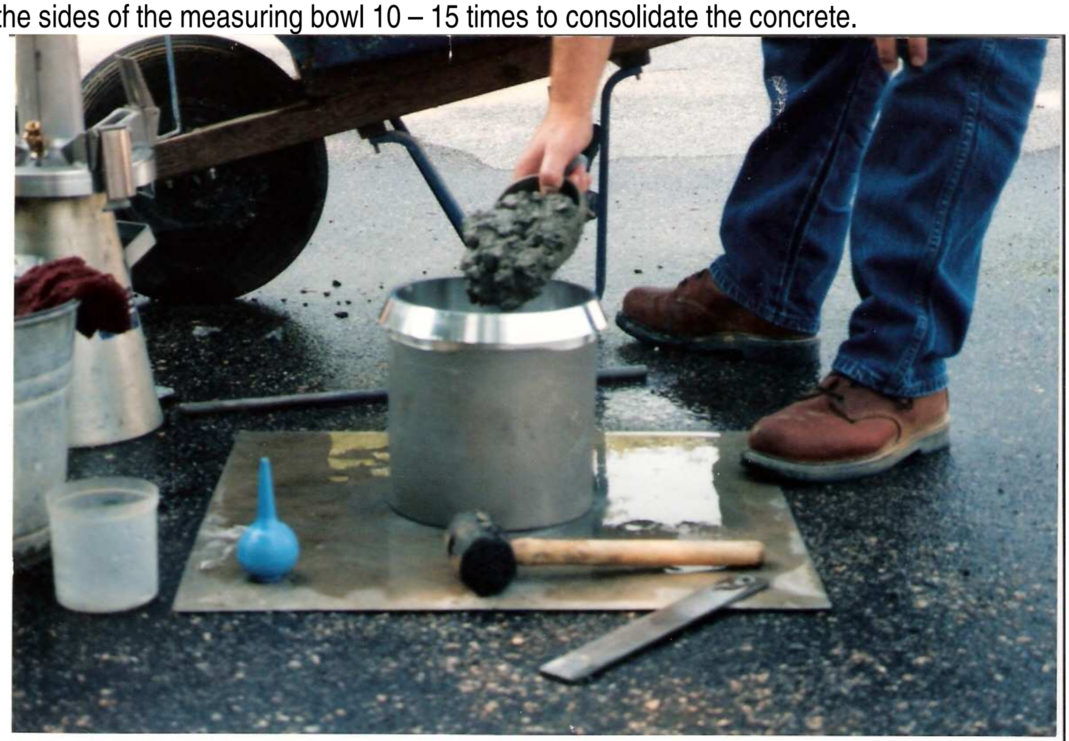
The equipment needed to run the air content test is shown above. Includes: a measuring bowl and cover assembly, a tamping rod, a scoop, a rubber mallet, a strike-off bar, a syringe, and a level surface. Thoroughly remix the sample of concrete prior to testing.

Clean the measuring bowl and all the equipment to be used, drain any excess of water.

Fill the first layer with concrete to about 1/3 of the volume of the bowl, distribute the concrete evenly.

Rod the first layer 25 times. Distribute rodding stokes over the entire cross section of the measuring bowl, penetrating the entire depth of the layer.

Tap the sides of the measuring bowl 10 – 15 times to consolidate the concrete.



The second layer is to be filled up to 2/3 of the volume of the measuring bowl (this is equivalent to filling up to 2/3 of the height of the bowl), distributing concrete evenly.

Rod the second layer 25 times, penetrating the first layer by 1 in.

Consolidate the second layer by tapping the sides of the bowl 10 – 15 times.

Fill the third and final layer (slightly overfill).

Rod 25 times, the rod penetrating 1 in. into the second layer. Distribute the strokes evenly.

Tap the sides 10 – 15 times to consolidate.

Remove all excess concrete with the strike-off bar, creating a smooth finish.

Clean the rim/flange of any concrete residue. The rim/flange must be clean moist before the cover assembly is applied. A damp rag or towel is helpful.

Moisten and clean the cover assembly gasket to ensure a good seal. Do not clean the lid over the base of the meter.

Note: NCDOT requires that both petcocks be closed **<u>prior</u>** to installing the cover assembly. Close the airbleeder valve (the rounded one on the air chamber, which controls the air pressure in the pump chamber). Install the cover assembly. Use the clamps to secure the cover assembly tightly on to the base. Secure opposite clamps simultaneously.

After installing the cover assembly, **<u>open</u>** both petcocks. Keep the bleeder valve **<u>closed</u>** (the rounded one located in the chamber). Use the syringe to inject water into one petcock until it flows out the other.

Keep both petcocks open. Check the gauge to make sure there is no prior pressure reading (the needle is in its "hands free" zone). Pump air into the air chamber until the gauge needle reaches the equipment's "initial pressure line". Allow a few seconds for the gauge to stabilize. Use the airbleeder valve to adjust the chamber's air pressure until the gauge reading is at its "initial pressure line" (each equipment can have its own, calibrated, initial pressure line).

Tap the gauge lightly, again, this will stabilize the gauge needle.

<u>Close</u> the petcocks. Press the air needle valve (the one with the lever) to release air in to the bowl base. Wait for the gauge needle to stabilize. Tap the sides of the measuring bowl with the mallet to relieve local constraints.

Tap the gauge lightly, and then repress air needle valve again to release any trapped air. Tap gauge lightly to stabilize. Read the percentage of air directly off the gauge. Subtract the aggregate correction factor and record.

PRESSURE AIR METER CALIBRATION INSTRUCTIONS

TYPE B

1. Screw short piece of tubing tightly into petcock hole on underside of cover (note which petcock). Fill base with water. Clamp cover to base.

2. Using syringe, inject water into petcock having short tubing until water is expelled through opposite petcock.

3. Pump until gauge reads slightly beyond pre-established initial pressure line (generally 3%). Wait a few seconds. If necessary, pump or bleed- off air to adjust gauge hand to initial pressure line.

4. Close petcocks. Press needle valve lever to release air into base. Wait a few seconds until gauge hand stabilizes. Gauge should read 0% if initial pressure line was correct. If two or more tests produce consistent variations from 0%, change initial pressure line to compensate for variation. Use new initial pressure line for subsequent tests.

5. Screw curved tube into petcock having short tubing. Open petcock. Press needle valve lever and fill calibrating vessel.

6. Open opposite petcock allowing water in curved pipe to run back into base. Base now contains 5% air.

7. Pump up air pressure to initial pressure line (3%). Close petcocks. Press needle valve lever. Wait a few seconds for needle to stabilize. Press lever again to release any remaining air. Gauge should now read 5%.

8. If two or more tests show gauge reads incorrectly at 5% air in excess of .2%, then reset gauge hand by turning recalibrating screw on gauge hand (on older meters, screw is on dial face).

9. When gauge hand reads correctly at 5%, additional water may be withdrawn in the same matter to check results 10%, 15%, 20%, etc.

*** Forney offers a full-time SERVICE REPAIR DEPARTMENT. Contact “Customer Service” @412-346-7400.

TYPE B PRESSURE AIR METER CALIBRATION

The equipment needed to calibrate the Type B meter is shown above. The meter base and lid, 5% calibration cylinder, tubing, and a surface that is stable and level.

Screw the short piece of tubing into petcock hole on underside of cover (note which petcock)

Fill the base with water

Securely clamp the lid onto the base. Alternate side clamps should be tightening simultaneously.

Using syringe, inject water in to petcock having short tubing until water is expelled through opposite petcock.

Pump air meter until gauge reads slightly beyond pre-established initial pressure line.

Wait a few seconds. If necessary, pump or bleed off air to adjust gauge hand to the initial pressure line.

Close the petcocks.

Press needle valve level to release air into base. Wait until gauge hand stabilizes. Gauge should now read 0% if initial pressure line was corrected.

Screw curved tube into petcock having short tubing. Open petcock. Press needle valve level and fill calibrating vessel.

Open opposite petcock allowing water in curved pipe to run back into base. Base contains 5% air.

Pump up air pressure to initial pressure line (typically 3%)

Close petcocks. Leave curved tube attached to lid.

Press needle valve lever. Wait needle to stabilize. Press lever again to release any remaining air. Gauge should now read 5%.

If two or more tests show gauge read incorrectly at 5% air in excess of 0.2%, then reset gauge hand. Remove cover from gauge to make adjustment.

Adjust the gauge hand by turning the recalibration screw on the gauge face. (For airpots issued by the department, the concrete technician should be contacted to make this adjustment).

VOLUMETRIC METHOD (ROLL-O-METER) ASTM C-173

Dampen roll-o-meter bowl. Pour off excess water.

Fill the 1st layer with concrete to about half of the volume of the bowl.

Rod the first layer 25 strokes

Tap the sides of the bowl 10-15 times to consolidate the concrete.

Slightly overfill the base. Rod the 2nd layer twenty five times, penetrating the 1st layer one inch. Tap the mold 10-15 times with the mallet to consolidate.

Remove excess concrete with a strike off bar, creating a smooth finish.

Clean the rim of any concrete residue.

Moisten and clean the lid gasket. Clamp top to the base.

Insert the funnel to add water.

Add at least 1 pint of water through funnel.

Measure the amount of 70% isopropyl alcohol to be used and add through the funnel.

Continue adding water though funnel until water level is visible in the glass.

Remove the funnel once the fluid level is visible in the glass.

Continue filling with water to the zero mark.

Once the water level is on the top mark (zero line), place the cap on.

Invert meter and begin agitation. The meter is agitated for a minimum of 45 seconds.

After a maximum time of 5 seconds, drop base downward. Invert and drop continually for a minimum of 45 seconds.

Begin the rolling process, vigorously rotating the meter forward and backward for minimum of 1 minute.

After rolling, set meter upright, remove cap, and let the fluid level stabilize for a minimum of 2 minutes. If the level does not stabilize within 6 minutes, the test is invalid.

Once the level is stable read the fluid level to the nearest quarter percent.

After the first reading, place the cap back on and begin the rolling process again for a minimum of 1 minute.

Remove cap, allow the fluid level to stabilize for a minimum of 2 minutes, and read to the nearest of quarter inch. The reading must be within quarter percent of the initial reading. If second reading is not within ¼ % of the first reading, the rolling process must be performed for a third and final time.

After the final reading is accomplished, disassemble the meter, dump out the contents of the base, and examine for undisturbed tightly packed concrete. If undisturbed concrete is present, the test is invalid. Also, if the 3rd reading, if needed, is not within ¼ % of the 2nd reading the test is invalid and a new sample is required.

The final air content is equal to the Final Meter Reading minus the correction for large amounts of alcohol plus the number of calibrated cups of water added. The air content is reported to the nearest quarter of a percent.

- When less than 2.5 pints of alcohol is used and calibrated cups of water are not added, the final meter reading is the air content of the sample of concrete tested.
- When 2.5 or more pints of isopropyl alcohol are used subtract the correction determined in Table 1 of ASTM C-173 section 4.

MAKING AND CURING TEST SPECIMENS IN THE FIELD (ASTM C-31)

1. Obtain a representative sample from the middle of the load by passing the receptacle through the entire discharge stream or divert the stream completely into the receptacle.

2. The minimum size sample obtained shall be one cubic foot.

3. Air, slump, and temperature tests must be run before cylinders are molded.

4. Transport the sample to the location at which the cylinders are to be made. The process of making the cylinders should begin no later than 15 minutes after obtaining the sample.

5. Cylinders should be made simultaneously. One sample consists of two cylinders.

6. After molding, the specimens should be left in place and protected for a minimum of 20-24 hours. The air temperature surrounding the cylinders shall be 60-80° F.

7. Cylinders should be transported to the lab no later than **72 hours** after molding.

8. Maintain the specimens in the field at a temperature of 60-80º F.

9. A sample card should be filled out and submitted with the cylinders.

10. Remove the molds at the lab and write project number, sample number, and the date made on each cylinder.

CHASE INDICATOR TEST (AASHTO T-199)

The equipment needed to run the chace indicator test is shown above.

Thoroughly remix the sample of concrete prior to testing.

Obtain a sample of mortar using the spatula, make sure to exclude particles greater than #10 sieve. Overfill the brass cup.

Rod the sample 10 – 15 times, tap the sides of the cup (say 10 -15 times). This will consolidate the mortar. If larger particles are detected during the rodding and/or tapping stages, remove them. If necessary, add mortar with the spatula, rod and tap the sides again.

Strike off any excess mortar to be flush with the top of the cup.

Clean the cup, insert the cup into the calibrated glass indicator. Fill indicator with 70% isopropyl alcohol to the top line of the stem (so the **bottom** of the meniscus is in line with the “zero” mark). DO NOT OVER FILL. DO NOT DISTURB CUP. Remove any excess alcohol by gently flicking your wrist, then add alcohol as needed so the bottom of the meniscus is in line with the “zero” mark.

Place thumb on the stem opening and gently roll indicator from a vertical to a horizontal position several times. While rolling with one hand, tap the sides of your rolling hand with your other hand.

With the indicator in a vertical position, count the number of marks from the “zero” line of the stem to the bottom of the meniscus of the alcohol level. Record to the alcohol level to **the nearest 0.25%** (this is your “stem reading”). Correct the air content using Tables 1 and 2 on the back of M&T Form 903. Record the air content to the nearest **0.10 %.**

Chace Indicator Example

- Indicator reading 3.25
- Chace Calibration 2.2
- Mortar Content 16.75

CHACE INDICATOR CORRECTION TABLES

Use only 70% Alcohol Table 1

Mortar Correction Factors

Mortar Content	Chace Indicator Scratched on glass Indicator								
Ft.^{3}/ yd	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
27	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40
20	1.19	1.26	1.33	1.41	1.48	1.56	1.63	1.71	1.78
19	1.13	1.20	1.27	1.34	1.41	1.48	1.55	1.62	1.69
18	1.07	1.14	1.20	1.27	1.33	1.40	1.47	1.54	1.60
17	1.01	1.07	1.13	1.20	1.26	1.33	1.39	1.45	1.51
16	0.95	1.01	1.07	1.13	1.19	1.25	1.30	1.36	1.42
15	0.89	0.95	1.00	1.06	1.11	1.17	1.22	1.28	1.33
14	0.83	0.88	0.93	0.99	1.04	1.09	1.14	1.19	1.24
13	0.77	0.82	0.87	0.92	0.96	1.01	1.06	1.11	1.16
12	0.71	0.76	0.80	0.85	0.89	0.94	0.98	1.03	1.07
11	0.65	0.69	0.73	0.77	0.81	0.86	0.90	0.94	0.98
10	0.59	0.63	0.67	0.71	0.74	0.78	0.81	0.85	0.89

Use Table 1 to get Mortar Correction Factor of 1.39

Air indicator stem reading 3.25 X 1.39 = 4.5 + _________ = _________ % Air

Factor Curve Corr.

Table 2

Curve Corrections

Mortar Corrected Air Content (%)	Curve Correction(%)	Mortar Corrected Air Content(%)	Curve Correction(%)
1.0	-0.1	7.0	0.8
2.0	0.0	7.5	0.9
3.0	0.2	8.0	1.0
3.5	0.3	8.5	1.1
4.0	0.3	9.0	1.2
4.5	0.4	9.5	1.3
5.0	0.5	10.0	1.3
5.5	0.6	11.0	1.5
6.0	0.7	12.0	1.7
6.5	0.8	13.0	1.8

From Table 2, get Curve Correction Factor of 0.4

Air indicator stem reading 3.25 X 1.309 = 4.5 + 0.4 = 4.9 % Air

Factor, Curve Corr.

Notes: When using Table 1, round the Mortar Content to the whole number. For example, 16.4 would round to 16. 16.5 would round to 17. To get the Curve Correction using Table 2, round the Mortar Corrected Air Content to the closest half. If the Mortar Corrected air is 4.7, use 4.5 on the table. If the Mortar Corrected air is 4.8, use the closest number, which is 5.0. Base the Curve Correction on the rounded number.

Chace Problem

- Mortar Content 16.37
- Chace Indicator Calibration 1.8
- Stem Reading 3.75

Air indicator stem reading ________ X __________ = _______ + _________ = ________ % Air

Factor Curve Corr.

Use the Correction Tables on the following page.

CHACE INDICATOR CORRECTION TABLES

Use only 70% Alcohol **Table 1**

Mortar Correction Factors

Mortar Content Ft.^{3}/ yd	Chace Indicator Scratched on glass Indicator 1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
27	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40
20	1.19	1.26	1.33	1.41	1.48	1.56	1.63	1.71	1.78
19	1.13	1.20	1.27	1.34	1.41	1.48	1.55	1.62	1.69
18	1.07	1.14	1.20	1.27	1.33	1.40	1.47	1.54	1.60
17	1.01	1.07	1.13	1.20	1.26	1.33	1.39	1.45	1.51
16	0.95	1.01	1.07	1.13	1.19	1.25	1.30	1.36	1.42
15	0.89	0.95	1.00	1.06	1.11	1.17	1.22	1.28	1.33
14	0.83	0.88	0.93	0.99	1.04	1.09	1.14	1.19	1.24
13	0.77	0.82	0.87	0.92	0.96	1.01	1.06	1.11	1.16
12	0.71	0.76	0.80	0.85	0.89	0.94	0.98	1.03	1.07
11	0.65	0.69	0.73	0.77	0.81	0.86	0.90	0.94	0.98
10	0.59	0.63	0.67	0.71	0.74	0.78	0.81	0.85	0.89

Table 2

Curve Corrections

Mortar Corrected Air Content (%)	Curve Correction(%)	Mortar Corrected Air Content(%)	Curve Correction(%)
1.0	-0.1	7.0	0.8
2.0	0.0	7.5	0.9
3.0	0.2	8.0	1.0
3.5	0.3	8.5	1.1
4.0	0.3	9.0	1.2
4.5	0.4	9.5	1.3
5.0	0.5	10.0	1.3
5.5	0.6	11.0	1.5
6.0	0.7	12.0	1.7
6.5	0.8	13.0	1.8

STUDY QUESTIONS

TESTING of PORTLAND CEMENT

(NCDOT SPECIFICATIONS)

THE TESTING OF PORTLAND CEMENT CONCRETE

1. In making a slump test:

   a. The cone should be filled in ___________ layers.
   b. Each layer should be equal ___________ .
   c. Each layer should be rodded ____________ times.
   d. The cone should be rapped with a rod ___________ times.
   e. The cone (should, should not) be rotated slightly when lifted.
   f. The cone should be raised within _______ to _______ seconds.
   g. In filling the slump cone, one-third of the volume of the mold fills to a depth of _______ inches; two thirds of the volume fills to a depth of _______ inches.

2. The amount of slump, as determined by the slump cone, is calculated by measuring the difference between the height of the mold and the height over the displaced center of the top of the specimen. (True or False)

3. Slump is a good measure of concrete.

   a. Consistency
   b. Flowability
   c. Setting time
   d. None of the above

4. Using the following information, determine the unit weight of a concrete mixture:

Weight of empty bucket	15.62 lbs
Weight of full bucket	52.69 lbs
Volume of bucket	0.33 Cu. Ft.

5. When checking the air content, the Pressure Method AASHTO T-152 is not as reliable as the Chace Indicator AASHTO T-199. (True or False)

6. When checking the air content on structure concrete, the Chace Indicator AASHTO T-199 should be run on the first load and a random load in each four load “lots” thereafter and when test cylinders are made. (True or False)

7. Concrete should have the desired slump before any type of air check is made or before test cylinders are made. (True or False)

8. What is the minimum size sample for preparing test specimens for concrete strength tests? (ASTM C-172)

    a. 0.1 Cu. Ft.
    b. 0.5 Cu. Ft.
    c. 1.0 Cu. Ft.
    d. None of the above.

9. What is the correct method to “perform sampling” (i.e., collect the concrete sample) when the concrete is delivered to a job site by means of a revolving drum mixer truck , or an agitator truck.
    a. Wait until the concrete is in the forms and perform sampling in the forms.
    b. Perform sampling by passing the receptacle through the entire discharge stream, or by diverting the stream completely so that it discharges into a container.
    c. Wait until the concrete is deposited in a bucket and perform sampling in the bucket.
    d. None of the above.

10. The sample should be remixed, (just prior to making the test specimens), protected from the sunlight and wind during the period between taking and using, but in no case when time exceeds:

    a. 5 minutes
    b. 10 minutes
    c. 15 minutes
    d. 30 minutes

11. When curing test cylinders for the first 20 to 24 hours, they must be kept moist and at temperature between:

    a. 40 to 50 deg. F.
    b. 60 to 80 deg. F.
    c. 90 and above
    d. none of the above

12. Test cylinders should be sent to the laboratory for standard curing, within 7 days. (True or False)

13. When test cylinders are being made on a truckload of concrete, what other type test should be run on the same load of concrete?

14. A mix design requires 33.5 gallons of metered water per cubic yard. Due to high temperature, 25 pounds of ice per cubic yard will be used. How much metered water is now needed per cubic yard using the ice?

SECTION VI

TERMS AND DEFINITIONS

AASHTO – American Association of State Highway and Transportation Officials

Absorbed Moisture – The moisture within the pores and capillaries of an aggregate.

Accelerator – A chemical, such as Calcium Chloride, used to "speed up" the setting time of concrete.

Acid Water – Water which contains concentrations of hydrochloric, sulfuric or other common acids.

Aggregate – An inert filler material, such as crushed stone, gravels, and sand which is mixed with cement and water to make concrete.

Air-dry – A condition at which an aggregate particle is dry on the surface but contains moisture within the pores of the aggregate.

Air Entraining Agent (AEA) – A chemical composed of surfactants which when added to concrete entrains microscopic air voids in the concrete.

Air Entrained Concrete – Concrete which has had an air entraining agent added to entrain minute air bubbles that are distributed uniformly throughout the cement paste.

Alkaline Water – Water which contains concentrations of sodium hydroxide, potassium, or other hydroxide.

Bleeding of Concrete – A condition whereby an excess amount of mixing water is accumulated on the surface of plastic concrete. This condition is caused by settlement and consolidation of the plastic concrete.

Cement – The bonding agent used in a concrete mix.

Cement Factor – The number of bags or pounds of cement in one cubic yard of concrete.

Coarse Aggregate – Aggregate larger than about 1/2" in diameter, usually referred to as stone or gravel.

Consistency – A condition of plastic concrete which relates to the repeatability of its plastic properties such as cohesion, wetness, and flow. The consistency of a concrete mixture can be measured by the slump test.

Daily Placement Operation – The amount of concrete placed per day of a designated concrete mix design.

Deleterious Substances in Aggregates – Undesirable substances that may be found in aggregates. These harmful substances include organic impurities, silty clay, coal lignite, and certain lightweight and soft particles.

Durability – The ability of hardened concrete to resist the deterioration caused by weathering (freezing, thawing, heating, cooling, wetting, drying, etc.) chemicals, and abrasions.

False Set – A significant loss of plasticity shortly after the concrete is mixed.

Fine Aggregate – A natural silica or manufactured aggregate smaller than about 1/4" in diameter, normally referred to as sand.

Fineness of Cement – The particle size to which cement is ground. The fineness of cement affects the rate of hydration. As cement fineness increases, the rate of cement hydration increases and causes acceleration in strength development.

Free Moisture – The moisture on the surface of an aggregate. The amount of free moisture is the difference between the total moisture and the absorbed moisture.

Freeze-Thaw Resistance of an Aggregate – A condition related to an aggregate's porosity, absorption and pore structure.

Harsh Mix – A coarse mix which is difficult to place and finish. This usually indicates that the mix does not contain enough fine aggregate to provide a dense, workable mixture. A harsh mix segregates easily because it is not cohesive.

Heat of Hydration – The heat generated when cement and water react.

Hydration – The chemical reaction between water and cement.

Loss on Ignition – Loss on ignition (LOI) is determined by heating a cement sample of known weight to between 900°C and 1000°C until a constant weight is obtained. The weight loss of the sample is then determined.

Mortar – Product resulting from combination of cement paste (cement, water, and admixture) and fine aggregate.

Natural Cement – A cement which has not been controlled in its making. It is generally found in its natural state.

Oven-Dry – A condition of an aggregate which contains no moisture either absorbed or free.

pH – The measure of hydrogen ion concentration. The pH value of neutral water is 7.0; values below 7.0 indicate acidity and those above 7.0 indicate alkalinity.

Placement Operation – The process of pouring plastic concrete in a structure, pavement, or incidental item. Each item is considered to be a placement operation. Items range from bridge decks to pave ditches.

Portland Cement – A manufactured product obtained by heating to a clinker and then pulverizing the combination of properly proportioned limestone, marl, shale, or clay, silica sand, and iron ore.

Portland Cement Concrete (PCC) – A concrete that consists of Portland cement, fine aggregate, coarse aggregate, water, and such admixtures as may be specified.

Saturated Surface Dry (SSD) – A condition at which an aggregate will neither absorb moisture from concrete nor contribute moisture to mix.

Set Retarder – A material composed of (1) calcium, sodium, potassium, or ammonium salt of lignosulfonic acid; (2) hydroxylated carboxylic acid or its salt; or (3) carbohydrates, except sucrose, that is used for the purpose of delaying the setting time of concrete. Retarders provide a lubricating effect and function as a water reducing agent also.

Setting Time – The time that it takes a cement paste to begin hardening.

Total Moisture – The sum of the moisture on the surface and the moisture absorbed into the pores and capillaries of an aggregate.

Unit Weight – The weight per unit volume. For concrete, the unit weight is pounds per cubic foot.

Water – The ingredient in a concrete mix that causes a chemical reaction with cement called hydration. The water assists in providing the necessary workability for the concrete.

Water-Cement Ratio (W/C) – The quantity of water divided by the quantity of cement (i.e, pounds of water per pound of cement) used in a concrete mixture.

Water Reducing Agent – Material used for the purpose of reducing the quantity of mixing water in concrete. This additive, which provides a lubricating effect, will cause an increase in slump and workability when placed in a concrete mix of a given consistency.

Workability – The property of freshly mixed concrete which is the ease or difficulty in placing and finishing of concrete. “Good workability” means that the concrete may be placed or finished with little difficulty and the mass contains a uniform gradation of aggregates. The slump test is not a measure of the workability.

DO'S AND DO NOT'S OF SAMPLING AND TESTING PORTLAND CEMENT CONCRETE

1. Do — Get a copy of approved DOT batch ticket from truck driver as soon as concrete arrives on project.

2. **Don't** — As DOT Inspector, instruct the truck driver to add water to a load of concrete (Contractor's Responsibility).

3. **Don't** — Sample concrete for any test until all water is added and mixing revolutions completed.

4. Do — Run Chace Air Indicator Test before allowing any concrete to be placed into forms (With calibrated Chace Indicator 70% Isopropyl Alcohol).

5. **Don't** — Sample the first quantity of concrete discharged from truck mixer for any test.

6. Do — Divert entire discharge stream into sampling container when sampling from truck mixer.

7. **Don't** — Sample concrete deposited on bucket or forms.

8. **Don't** — Exceed allowed water/cement ratio.

9. Do — Take Representative Sample — (For cylinders out of middle portion of load).

10. Do — Take minimum size sample when making test cylinders of one cubic foot.

11. Do — Run all tests according to prescribed procedures.

12. Do — Remix sample thoroughly before running any field test.

13. **Don't** — Use concrete for more than one field test.

14. Do — Run all field tests immediately after securing the sample with all test being completed within 15 minutes after the sample is taken.

15. Do — Protect and cure cylinders first 20 to 24 hours after making and get them to the Laboratory for standard curing and protection as soon as possible after first 24 hours, but no later than seven days after making.

16. **Don't** — Make cylinders where there is any movement or vibrations of heavy equipment, etc., that may damage them during first 20 to 24 hours.

17. Do — Rerun any failing field test before rejecting a load of concrete.

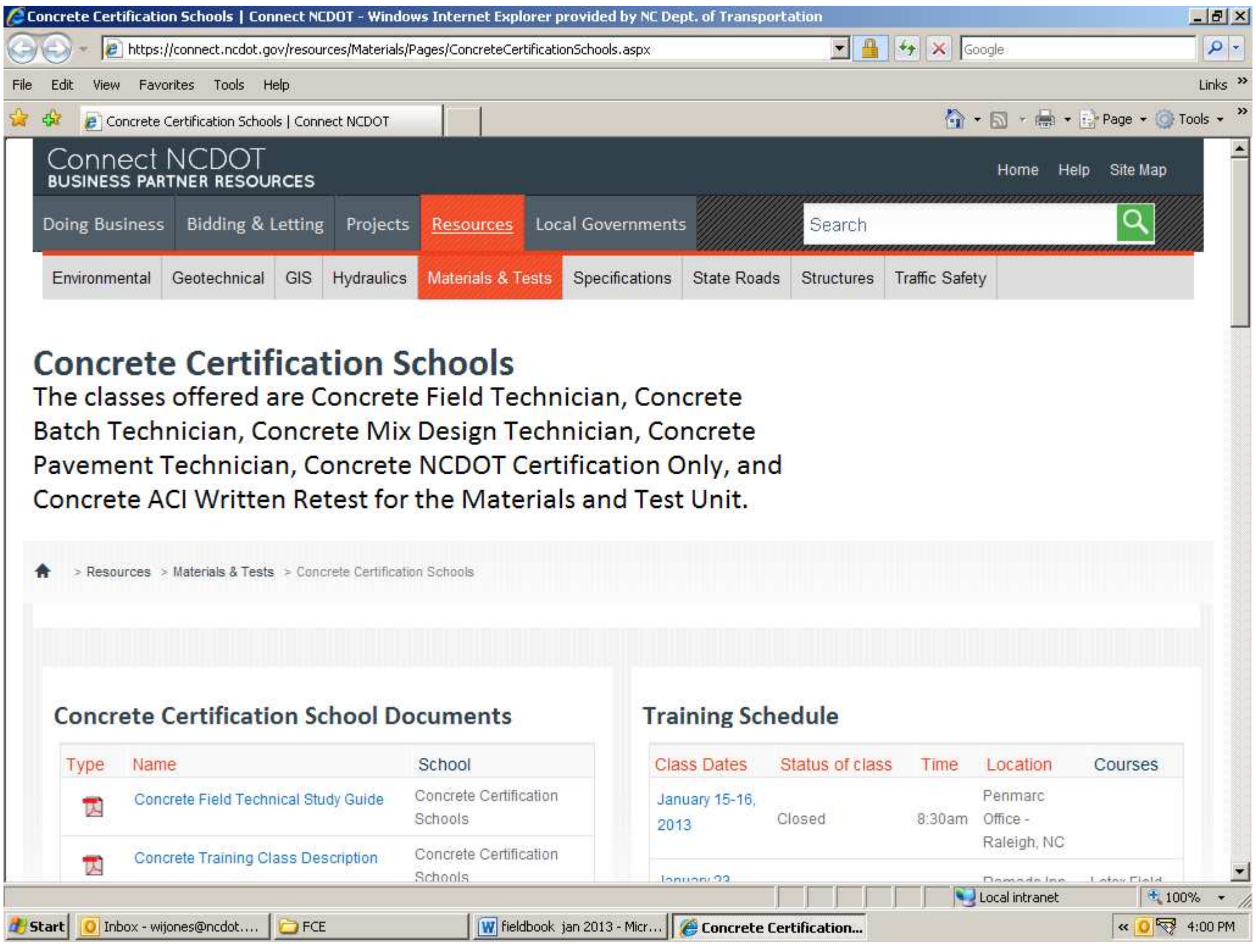
18. **Don't** — Move cylinders after they are made within first 20 to 24 hours (Cylinders may be moved immediately for protection).

19. Do — Record all field test accurately and sign name certifying accuracy of information.

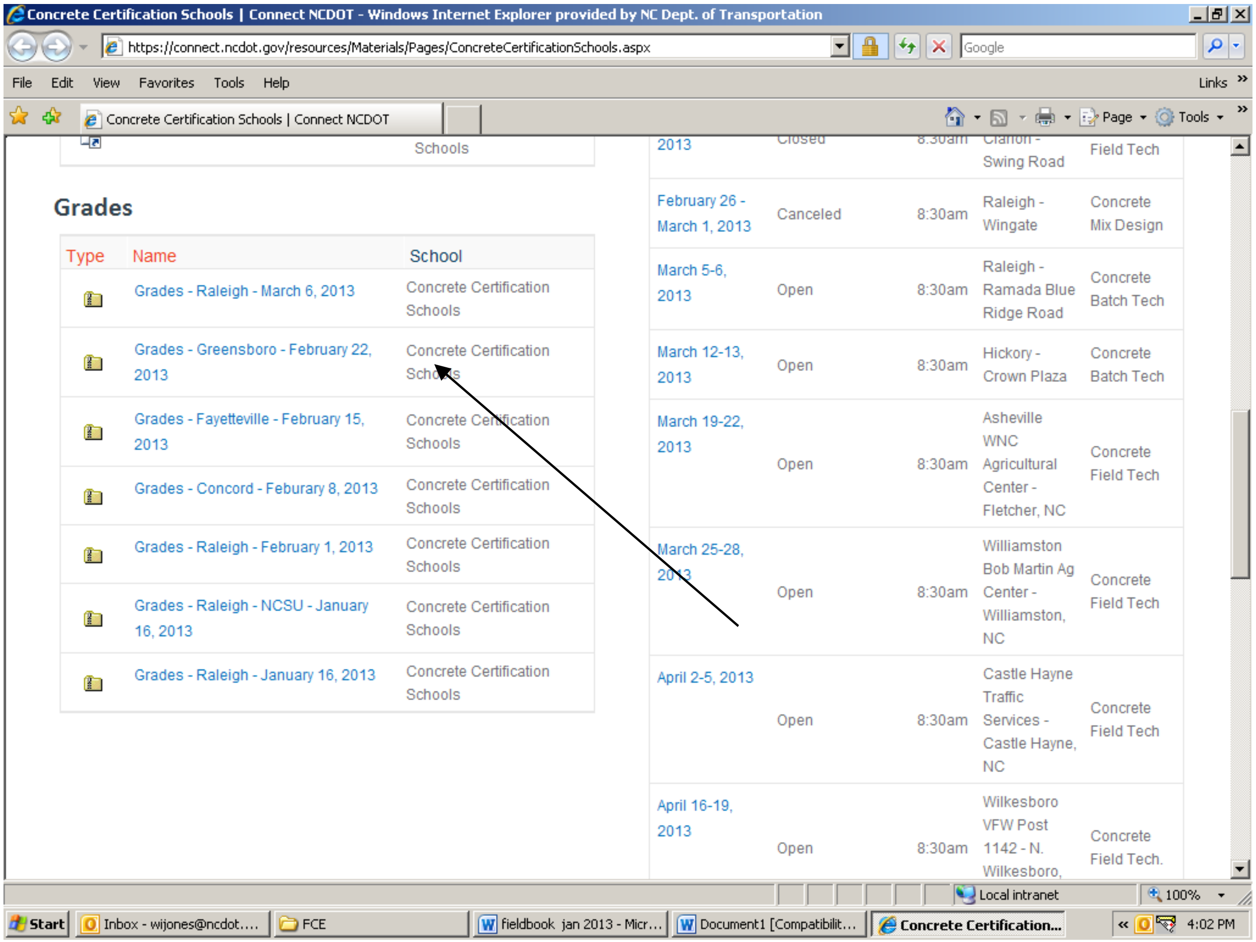
ASSESSING NCDOT TEST RESULT FROM M&T WEB PAGE

The written tests will not be graded in the classroom. To learn the test result, assess the M&T web site one week after the test date to view score. A letter with the test results and the Batch Certificate will be mailed out two weeks after the test date. Batch Certificate will be granted based on successful completion of the class to Technicians currently Concrete Field Technician certified. Directions to access the M&T web site are below.

- Type www.ncdot.org/~mtu in the web address bar



- Scroll toward bottom, looking left



- Select Concrete Certification Schools
- Click on the Concrete Certification Grades
- Locate the date, class, and site where test was taken

The grade will be listed by the first letter of last name and the last 4 digits of the Social Security number

SECTION VII

Course Evaluation

Chace Indicator Check List

Materials & Tests Unit

NCDOT

CONCRETE SCHOOL
COURSE EVALUATION

MATERIALS AND TEST UNIT
NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Course Title: ____

Site Location: ____

Instructors: ____

FACILITY	ADEQUATE	INADEQUATE
Location of the course		
Classroom Size		
Temperature		
Seating and Workspace		
Breaks		
Comments:		

5 = very good; 1 = poor

COURSE	5	4	3	2	1	N/A
Course requirements were clear.						
Length of course was sufficient.						
Course was organized.						
Manual was helpful.						
Test was fair.						
Comments:						

INSTRUCTOR	5	4	3	2	1	N/A
Instructor was organized.						
Instructor was knowledgeable of the subject.						
Time allotted for this portion sufficient.						
Answered all questions sufficient.						
Will you be able to use this information?						
Comments:						

AUDIO-VISUALS	5	4	3	2	1	N/A
Audio-visuals were interesting						
Audio-visuals were of good sound quality						
Audio-visuals were of good visual quality						
Contributed to learning:						
Comments:						

PLEASE ANSWER THE FOLLOWING HONESTLY:

Will this course help you do a better job, and how did this course help you? ____________

____

____

____

____

____

How could this course be improved? ____

____

____

____

____

____

What was most beneficial? ____

____

____

____

____

____

Any Additional comments: ____

____

____

____

____

____

____

____

STUDENT NAME ____

RESIDENT ENGINEER OR COMPANY ____

STUDENT NAME ______________________________ **4 digit SS** __________

Checklist Chase Indicator AASHTO T-199-00 (NCDOT Modified)

	TRIAILS 1ST	TRIAILS 2ND	RETRIAL
1. Fill brass cup with mortar. Do not consolidate during filling. Exclude particles of sand which would be retained on a 2.00 mm (No. 10) sieve.	____	____	____
2. Rod the mortar in the cup using a thin stiff wire (No. 1 GEM paper clip). If detected during rodding, exclude particles of sand which would be retained on a 2.00 mm (No. 10) sieve. Consolidate by tapping the side.	____	____	____
3. Strike off mortar flush with top or the cup.	____	____	____
4. Insert cup into glass tube and add alcohol to the "0" reference on the stem. Make sure the bottom of the meniscus is in line with the "0" reference line.	____	____	____
5. Be careful not to change setting of the stopper.	____	____	____
6. Roll and tap the indicator until all mortar is dispersed in the alcohol and no more bubbles appear.	____	____	____
7. Read and record the stem reading to the nearest ¼%.	____	____	____
8. Calculate the air content to the nearest 0.1%	____	____	____
	(Circle One)		
Overall Score	Pass Fail	Pass Fail	Pass Fail

I certify that I have not helped, coached, or any way interfered with the examinee during this performance examination.

Examiner ______________________________ ______________________________
Name Date